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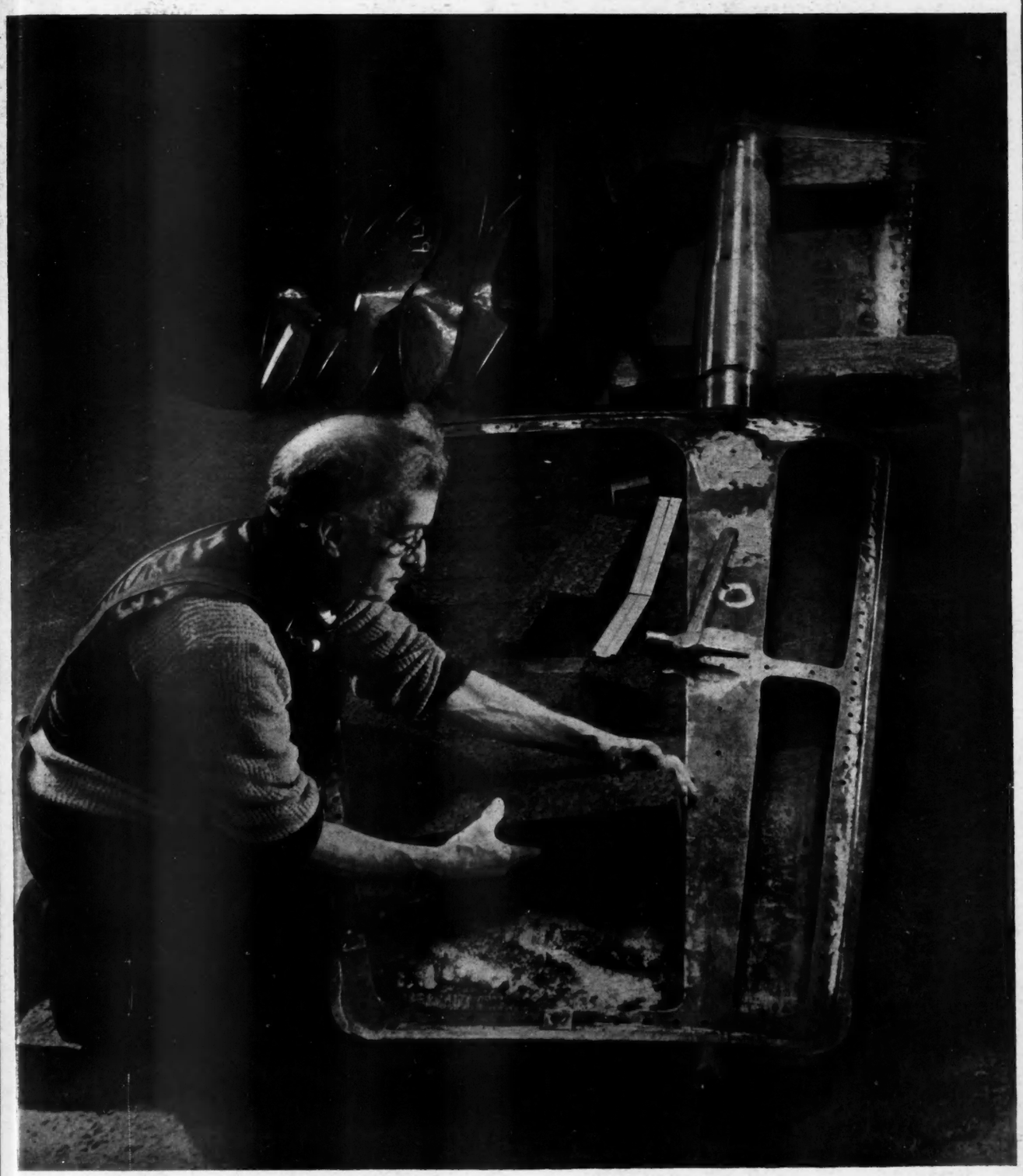

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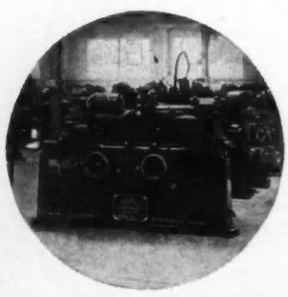

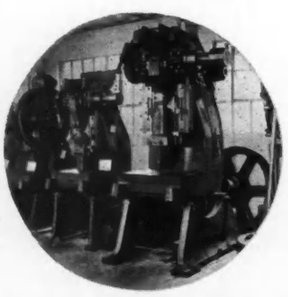

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Vol. 178 No. 4624 SEPTEMBER 10, 1954

Leading Article

A Better Way 321

Principal Articles

Effect of New Materials on Engineering Progress 325
The Scottish Industries Exhibition 326
British Association Meeting. Discussions on:
Efficient Steam Generation 327
Use of Firedamp from Collieries 327
Vehicle Characteristics and Road Accidents 328
The Eclipse of the Engineer in Management 329
The Efficient Generation of Industrial Steam: Reducing Losses in Flue Gases 335
Vehicle Characteristics and Road Accidents: Effects of Design and Maintenance 339
Balancing Machine: Electronic Indicator for Dynamic Corrections 345
High-Power Stroboscope 345
22-kV Submarine Power Cable: Laying Successfully Completed in the Outer Hebrides 345
Aircraft Industry's Display at Farnborough: 2 – Fighters, Ground Attack Aircraft, and Engines 347
Shielded-Arc Welding Plant with Water-Cooled Gun: High-Speed Welding of Difficult Materials 349
"Supercharged" Propeller Turbine: Good Performance at High Altitudes 349
Air Liner for Short and Medium Ranges: Two Handley Page Prototypes under Construction 350
Coal-Burning Gas-Turbine Locomotive: The North British Locomotive Co. Design 351

Weekly Survey

Planning and Costing 322
Design and Production 322
Managers and Men 322
Education of the Industrial Engineer 322
Indian Steel Capacity 323
Glasgow Railways 323
African Iron-Ore for the U.S.A. 323
Nuclear Physics 323

Obituary

Sir John Kennedy, O.B.E. 324

Personal 324

Business Changes 325

British Standards 334

Books Received 334

Trade Publications 334

Launches and Trial Trips 344

Contracts 348

Notices of Meetings 351

Labour Notes 352

News

Materials Handling 334
The "Saxonia": Maiden Voyage of Cunard Liner 345
Street Lighting in Britain: Eastbourne Conference 348

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A BETTER WAY

Is there a philosophy of engineering – an approach founded on certain generally accepted but unformulated conceptions of craftsmanship and professional conduct? In this country such a philosophy springs to a substantial degree from the engineer's early experience as a pupil or apprentice. He acquires the conviction that excellence in engineering, is a worthy aim in itself.

It would be folly to discard this guiding principle under the pressure of economic circumstances, but perhaps it is not incompatible with a fresh conception of the function of engineering in the industrial life of the nation to-day. No one can reasonably doubt the constant need to question the accepted order, to determine whether the original assumptions on which that order has been built still hold good, or whether, as often happens, the assumptions have long since been forgotten and the order is being carefully perpetuated, buttressed against the impact of new factors and forced to serve a purpose which it was never intended to serve.

Praise is due to thirteen men who have given us a guide-book. The last of the productivity-team reports to be published, their work is perhaps the greatest of the series because they had the widest brief of all: "To investigate the dynamic and aggressive American approach to improvement of methods of manufacture and to continuous reduction of operating costs." Their inquiry led them to seek the base of the pyramid of social and commercial life, and although it may be argued that they failed to reach the true base (nothing less than immense historical research could achieve that), they have at least produced an analysis which touches on every major point and will stimulate (or provoke) every engineer who reads it.

The team believe that there are five characteristics of American industry which are relevant to British requirements: the sharp and urgent competitiveness of the economy, the greater availability of finance for capital investment, the lower impact of taxation, the non-stratification of society, and high wages. They pose the question "Why is American business so competitive?" but they may be forgiven for failing to answer it adequately. Their answer is "more than any other factor, competition provides the drive for the more frequent analysis of costs and the application of industrial engineering techniques in the U.S., and the constant effort to achieve the most economic usage of men, materials, machines and money." The title of the report is "Industrial Engineering," and much of the report is concerned with the industrial engineer – a term which is not wholly accepted even by Americans. The team's definition of industrial engineering is "the application of basic scientific and engineering knowledge and certain analytical techniques to the methods of operating an organisation in industry and other appropriate fields. It requires investigation into the economic advantages of one policy as against another and implementation of the most suitable procedure for raising productive efficiency. To achieve this, performance and cost need to be checked."

The detailed findings of the team are summarised in Weekly Survey notes on the next page. The message of the report, however, is closely connected with Mr. Bosworth Monck's paper to the British Association, which is published in this issue of ENGINEERING. Mr. Monck has carried out a most commendable survey of the status of the engineer in management – a survey which will undoubtedly initiate discussion wherever management and engineering are interdependent. His conclusions, based on a formidable array of evidence, are that the status of the engineer in management has declined steadily in this country, and that the decline has coincided with a reduction in the British share of world trade in engineering. He is not prepared to label the latter as the symptom and the former as the cause, but he regards the parallel as significant. His solution is to have a higher proportion of engineers on the boards of directors of engineering (and, in some cases, other) companies.

The implication that the quality of boards would be automatically raised by such a transfusion of engineering blood cannot be accepted without question. Lord Halsbury recently expressed the opinion that the relation between a technologist and the board to which he is promoted must be considered as reciprocal. Engineers as engineers will have much more to learn from, than to contribute to, board meetings. The reason for this is that boards do not embark on technical controversies. They engage technologists to do this for them; whether they are employees, consultants, or members of the board, their advice is that which is acted on, not discussed on its merits. The function of a board, he argued, is to formulate policy in terms of the advice of experts in different fields, whose recommendations may be and often are in conflict with one another, as when the technologist proposes and the accountant rejects for reasons of apparent cost or capital shortage. The technologist promoted to the board must, on this view, at first forget that he is a member of a rational professional community, cultivate his intuitive faculties and learn to make policy decisions on insufficient or conflicting evidence.

Weekly Survey

The last productivity team report to be published is the subject of a leading article on the previous page. The main points from it are summarised in four notes below. There is not a branch of the engineering industry and profession which is not affected by the team's findings. *Industrial Engineering* is obtainable from the British Productivity Council, 21 Tothill-street, London, S.W.1 (price 5*s*. post free, excluding air mail); and from the Office of Technical Services, Department of Commerce, Washington, D.C., U.S.A.

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PLANNING AND COSTING

" Industrial engineering " is an attitude of mind just as, say, work study is basically an attitude of mind towards job evaluation. It is therefore not surprising that the team should endorse much of American practice, especially as they no doubt saw some of that practice at its best. The report emphasises the important part played by preparatory planning in American industry. The team noticed that more American firms plan their future programme of production on a system of conferences between heads of departments than is common in Britain. It is customary for American pre-planning to begin with market research so that the company is sure that the demand exists for the product under consideration. This is usually followed by an inter-departmental conference where sales, purchasing, planning, production and costs are all represented. The industrial engineer is present as a member of the planning department. The team found that the production planning departments and the cost departments have far more influence on policy at this stage than is common here, and that even at this stage an American company will be working on a calculated selling price which has been evolved from the marketing inquiry. From these preliminary meetings come preliminary drawings which are submitted to the industrial engineering department for examination. One of the key objects at this stage is the reduction of costs by the adjustment of drawings for ease of production.

The importance of using costing as a tool of management, and the development of standard costs to control efficiency along with some form of budgetary control, is emphasised in the report. The American attitude on costs can perhaps be summed up in the phrase that quickness is more necessary from the point of view of management's control of production than complete accuracy – a doctrine which cannot be extended of course to the accounting department. The report, however, emphasises the need to give cost accountants some training in the works if their full potentialities in the planning of production are to be properly used. But even this emphasis on the need to keep costs down by using the costing staff properly in co-operation with the engineers is only part of the more fundamental problem, according to the report, of maintaining as wide a statistical control of production as possible. Speed and accuracy could be improved, in the team's view, by speeding up the trend towards carrying out complicated calculations by the use of electronic computors.

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DESIGN AND PRODUCTION

A major factor in production control, according to the report, is the extent to which American firms make use of sub-contracting, particularly for the supply of tools and fixtures. A firm's tooling programme may fluctuate too widely for a full permanent staff to be maintained. By using sub-contractors the interval between design and production is minimised, thus enabling the firm to keep up with competitors. Additional or improved tools can enable jobs to be done by unskilled workers, and sometimes it is found to be economical to let machines stand idle between runs rather than spend time on resetting.

Care is taken at the design stage to ensure that the design suits the method of production: at one plant, tool engineers from the industrial engineer's department were present the whole time a new design was being worked out. Designs are not " over-engineered "; nor the method of manufacture subordinated to functional design. " The design is only made once on the drawing board, but the product is made many times with machines and labour." The use of effective standards was described by a leading American industrialist as " one of the most reliable tools an executive can have to reduce the pressure under which he lives." In works stores, standardisation has led in some British firms to a reduction of 50 per cent. of stocks. (The approach to this problem of eliminating unnecessary holdings has been thoroughly worked out in Great Britain by Mr. E. G. Brisch, whose system has been applied with remarkable results by many firms, large and small.)

Statistical quality control is used to maintain a high rate of production, the resulting economy more than off-setting the cost of replacing faulty components. And data from quality control charts are sometimes used by the plant engineer as an indication of the condition of machines. The team were surprised at the seeming lack of maintenance in most of the plants visited, but there is a growing realisation in the United States that the policy of scrapping a machine when it is worn out cannot continue, since it incurs a vast squandering of the country's natural wealth. In some plants, maintenance is now carried out during a third (i.e., night) shift.

Production control plans are worked out with great care and a determination to adhere to them. A notable feature is the use of a separate drawing for each operation on a component. Instead of the usual single drawing for each component, a series of drawings is prepared showing, in each case, the position it occupies in the machine for each operation. Only the dimensions necessary for that operation are indicated. In preparing for production, the problem of materials handling is approached analytically, in the knowledge that handling costs represent a surprisingly large part of total costs and offer a correspondingly significant opportunity for reduction. Packing the finished product is regarded, ideally, as the final stage of assembly; not simply a separate job to be done after production. This links up with the growing use of predetermined motion-time systems (referred to in the note on " Managers and Men " below) which enable production methods to be planned as nearly perfectly as possible before production actually begins – in contrast to conventional motion study and time study which seek to better existing methods.

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MANAGERS AND MEN

The interest of the report so far as work study is concerned is less in the comments which are made on time and motion study, since it can be assumed that such techniques are widely employed in the United States, than in the growth of pre-determined motion-time systems and the care which is taken to ensure that the operation of such systems is understood at all levels of management. Some detailed figures on pre-determined motion-time standards are given in an appendix to the report. Incentive payment schemes were found by the team to be in operation in many works and they found many variations of simple types. These ranged from ordinary incentive payments to participation in cost-saving schemes such as the well-known Scanlon plan. Generally, American unions were found not to favour incentive schemes but to prefer a flat time rate.

So far as the more formal efforts to bring management and labour together in the works are concerned, the team found that joint consultation committees are not widely favoured in the United States. The unions consider that it is the job of management to manage and the job of trade representatives to represent the worker on matters affecting working conditions. On the other hand, suggestion schemes seem to be both popular with workers and worthwhile and helpful to the firms. So far as safety precautions are concerned, the report makes the good point that education in safety is considered more important than safety devices and regulations. Companies are very conscious of the need to ally workers sympathies with the interests of the company and care is taken to keep operatives informed about the company's policy and schemes for the future. The Americans do not assume that management and labour should discuss company policy only in the field of welfare. House magazines, for example, print articles on production policy and planning. The team also put in a plea for the revival of the foreman's influence in the factory – an influence which has not been impaired in American industry as it has in this country.

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EDUCATION OF THE INDUSTRIAL ENGINEER

The report calls on British universities and technical colleges to expand their industrial engineering studies, both in single subjects and in courses. Education of this type is essential for training men who will " enter industry with the conviction that the practice of to-day will be swept aside tomorrow, and that it will be their job to do it." True, some British universities are offering courses which include industrial engineering subjects, but so far they have few students. Some American executives value shop-floor training, as it is valued in this country, but the drift of American opinion suggests that in the future direct entry into a works will serve for the training of technicians only, and that it will become harder and harder to acquire full industrial engineering status without long systematic training.

A typical American course in industrial engineering includes the following subjects: manufacturing, product design, fabrication, machine applications, materials selection, inspection, packaging, plant layout, materials handling, transportation, personnel and labour relations, economic applications and costs, and statistical methods, as well as organisation, management and administration. Some American industries run courses within their own plants for the development of industrial engineers. A strong emphasis on costs is characteristic of American courses. Changes are taking place so rapidly that continuous adjustment is recognised as necessary; this adjustment is made most economically by organised educational action. Companies observe their executive staffs, to seek out potential ability and to provide for its development by education.

Even old-established professional institutions

such as the American Society of Mechanical Engineers give prominence to industrial engineering subjects. Since the societies are not concerned with professional qualification, they are prepared to seek their membership in a much wider field than is usual in the United Kingdom; and this in turn makes them more responsive to new ideas and techniques. In research, Americans now agree that hitherto they have relied too much on the basic research of other countries, particularly Britain. Which nation will act quicker: America in expanding basic research; or Britain in expanding industrial engineering?

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AFRICAN IRON-ORE FOR THE U.S.A.

Far-reaching changes are being forced upon the iron and steel industry of the United States as the rich iron ores in the Lake Superior region approach exhaustion. Large sums have been spent on plant for " benefication " of lower-grade ores in the district, and the development of foreign ore sources has called for heavy capital outlay and some movement of the iron and steel industry to new regions on the seaboard best suited to handle the imported ore. Fortunately, the transport of the Labrador ores, which are now being developed, to the ore-handling ports of the Great Lakes, will be cheap and easy when the St. Lawrence Seaway is completed. Labrador is expected to yield about a million tons of high-grade ore this year, and output should quickly reach 10 million tons a year. This is, however, far short of total United States requirements of foreign ore, which have been estimated at up to 40 million tons per annum within the next 15 years. In 1953 imports had already reached 10 million tons, compared with a home production of 117 million tons.

The foreign sources at present being exploited include Venezuela, Chile, and Liberia and Peru. The El Pao mines in Venezuela, owned by the Bethlehem Steel Company, exported 2 million tons in 1953, and the Cerro Bolivar mines of the Orinoco Mining Company are expected to export 3 million tons this year, and eventually perhaps 10 million tons per annum. Liberia and Peru each yielded over half a million tons in 1953, and Chile, 2·5 million tons from the El Tofo mines of the Bethlehem Steel Company. This company, which has yet another project in Peru at El Romeral, has been particularly active abroad and has now announced its intention of developing ores in South West Africa at a cost of £30 millions. Two years have been spent surveying the Kaokoveld, where there are two main deposits estimated to contain sufficient ore for mining at the rate of 3 million tons a year for 75 years. The ore contains impurities, but the problem of their economic removal, which is at present being studied, is not expected to be unduly difficult. If it is successfully solved, Bethlehem Steel will build a railway 100 miles in length to connect the deposits with Rocky Point, where a new harbour will be constructed.

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INDIAN STEEL CAPACITY

The Association of Indian Trade and Industry in Bombay recently published a study on the combined effect of inflation and conservative accounting methods on the assets of the Indian iron and steel industry. As in other countries, apparently, the steel industry has had difficulty in preserving the real value of its assets as prices have risen. Nevertheless, progress continues to be made with the expansion of the Indian iron and steel industry. The much publicised scheme for a steel plant of 500,000 tons a year capacity under the control of the Government of India and the Hindustan Steel Board in collaboration with the German consultants, Krupps and Demag, has now gone a stage further with the approval of the preliminary report. There are also reports of the willingness of the Russians to sell steel plant to India under the recent commercial agreement signed between the two countries.

The output of the steel industry in 1953 was 1,470,000 ingot tons, a slight reduction on the 1,580,000 ingot tons produced in 1952. Output by 1958, under the 1953 five-year development plan, is scheduled at 2,250,000 ingot tons, an increase of 42 per cent. on the 1952 figure. It will be recalled that the Steel Corporation of Bengal Limited was recently merged into the Indian Iron and Steel Company, Limited, and the output of this new combine was probably about 450,000 tons in 1953. The other large steel company in India is the Tata Iron and Steel Company, Limited, which was probably operating last year at a rate of about 750,000 tons a year. It is apparent therefore that these two together account at present for about 80 per cent. of India's total steel output. The Tata Company is expecting to increase its output by about 20 per cent. over the current year in the next three or four years, and the five-year plan allows for further expansion of the Burnpur Works – the integrated plant which arose from the amalgamation of the Steel Corporation of Bengal and the Indian Iron and Steel Company. The State Governments (in contradistinction to the Central Government of India) have a number of expansion programmes in hand for the steel industry, including the Mysore Iron and Steel Works, which is due for completion this year or next. These provincial schemes will add about 60,000 tons of finished steel a year to the country's output. When all these various plans are put into operation, however, it would appear that the Indian Minister of Production's recent statement about the need for a second unit, in addition to the one already in hand with the German consultants, was fully justified if the five-year plan for steel production is to be fulfilled. It may well be that the Russian plant will be incorporated in the first or second of these Government projects.

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GLASGOW RAILWAYS

Electrification of the railways around Glasgow, a project which has been mooted for many years, has been agreed to by the British Transport Commission, who have put the proposal to the Glasgow Passenger Transport Committee – a committee representing British Railways, the Scottish 'bus group, and Glasgow Corporation – as a contribution towards relieving the transport problems in Glasgow and district. The lines which it is contemplated would be the first to be electrified would be the Airdrie to Helensburgh/Balloch and the Cathcart Circle. These serve heavily-populated areas, and loop lines have been suggested to take in new large housing schemes along the routes. The cost of the scheme has been estimated roughly at £5 millions for the first stages and a total of £11 millions.

At a meeting of the Glasgow Passenger Transport Committee on Monday, September 6, Sir Ian Bolton, chairman, made it clear that the Transport Commission were satisfied that the electrification of the suburban lines in and around Glasgow, broadly as suggested in the Inglis Report, would probably result under the present circumstances in a substantial loss to the Commission. Nevertheless, the Commission thought that electrification was an essential part of any satisfactory solution of the Glasgow transport problem. A sub-committee was then formed to prepare a report which will suggest the most effective manner in which co-ordination of services might be provided to ensure adequate facilities for the travelling public. It will proceed broadly on the understanding that any proposals would be on the basis of a recognition of the interests of Glasgow Corporation and the Transport Commission. Neither party, however, would be bound to accept the recommendations.

A scheme for electrifying rail services in Glasgow and the Clyde Valley area formed a major part of the Inglis Report, issued in November, 1951; it envisaged fast and frequent services for most suburban traffic, electric trains linking Glasgow with Helensburgh, Balloch, Airdrie, Paisley, Gourock, and Wemyss Bay being suggested as a first stage in the development. The Inglis Report was quickly criticised on the grounds that railway electrification at existing fare levels would be extremely hazardous. Two years later the chairman of the Railway Executive said that although the immediate prospects of electrification in the area were not very good, it was clear that Glasgow's transport problems must be tackled as soon as possible. A month later representatives of the Scottish Council (Development and Industry) and the Clyde Valley Planning Advisory Committee reached complete agreement on the need for the electrification of suburban and district rail services in Glasgow and the Clyde Valley. At the same time three Glasgow Corporation committees approved the Inglis Report in principle, including the plans for electrification of the railways.

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NUCLEAR PHYSICS

The president of section A of the British Association this year is Sir John Cockcroft, K.C.B., F.R.S. and in his presidential address to the section on September 2 he outlined some of the recent developments in nuclear physics. Sir John began by saying that the post-war developments in this field were as exciting as those when Rutherford was president of the section in 1909 and the idea of the nuclear atom was being conceived. Rutherford again addressed the Association in 1923, also as president, and these two were the last addresses devoted to nuclear physics. Since that time great progress had been made, and the modern accelerators and symchrotrons (the latest envisaged a step up to 25 billion volts) offered even greater facilities for the future.

Experiments had been conducted on the scattering of nucleons by individual nucleons – protons from protons and then from neutrons – which had led to a better understanding of these particles. Other experiments had been on mesons – which were created in collisions of high-speed protons with other nuclei – and several types had been identified. All had short lives, but played a part in the forces of the nucleus. Experiments on them would be greatly facilitated in this country by a linear accelerator which was being constructed in an open area at Harwell. This was designed to produce 600-MeV protons which would be guided to bombard a liquid-hydrogen target and so provide mesons. The apparatus would be for the use of British physicists generally.

Sir John closed his address with a note of warning and a word of hope. He drew attention to the disaster which must attend a full-scale atomic war and to the effect on the mutation rate that radiation has. In contrast, he showed how, used for peaceful ends, atomic energy could be used to provide a source of power without limit, for all man's needs.

Obituary

SIR JOHN KENNEDY, O.B.E.

Former Electricity Commissioner

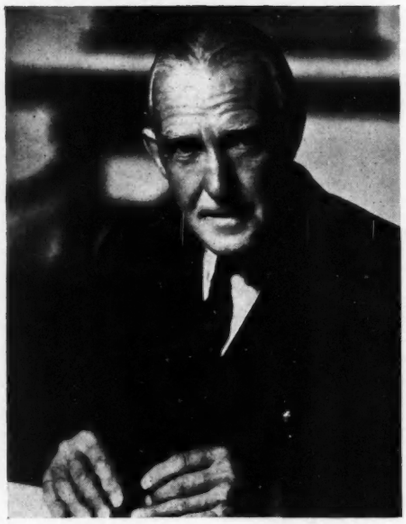
Electrical engineers, especially those who are engaged in power supply, will learn with regret of the death of Sir John Kennedy, which occurred at Shalford, Surrey, on Tuesday, August 31, at the age of 74. He had for many years played a leading part in the development of electricity supply, both at home and abroad, especially as an Electricity Commissioner and as consulting engineer to the Central Electricity Board and later to the British Electricity Authority. To a deep technical knowledge he added a genial and unassuming manner which greatly endeared him to all those with whom he came in contact.

John Macfarlane Kennedy was born in London on October 12, 1879, being the eldest son of Sir Alexander Kennedy who was a pioneer in electricity supply and was also president of both the Institutions of Civil and Mechanical Engineers. He was educated at University College School, London, and Trinity College, Cambridge, and after obtaining his degree studied at the Zurich Polytechnic and received a practical engineering training with Richard Moreland and Sons, Willans and Robinson, Limited, and in the Berlin works of Siemens-Halske.

He subsequently joined the consulting engineering firm which his father had established in partnership with Mr. C. F. Jenkin, and became a partner in 1908 at the age of 29. By that time Sir Alexander had carried out important work in London for the Westminster Electric Supply Corporation, the Central Electrical Company and the St. James' and Pall Mall Electric Supply Company, and had been responsible for the establishment of electric power stations in Edinburgh, Glasgow, Manchester, Belfast, Croydon, West Hartlepool, York, as well as at many places abroad. He had also designed the electrical equipment for the Waterloo and City Railway and prepared the plans for the electrification of the Hammersmith and City Railway in the west of London. His son was associated with him and with Mr. S. B. Donkin (who had become a partner in 1908 on the retirement of Mr. Jenkin) in much of this work, which later included a scheme for the electrification of the south eastern section of what is now the Southern Region of British Railways.

During the 1914-18 war John Kennedy became technical assistant to the Chief Engineer, Central Force, and was later chief engineer on construction work. Then from 1916 to 1918 he was superintendent of the Government rolling mills at Southampton. For his work in connection with these services he was appointed an Officer of the Order of the British Empire in 1919.

He returned to civil life at a time when the re-organisation of the electricity supply of the country on national, rather than parochial, lines was engaging the attention of both engineers and politicians. The result of the activities of the latter was the passing of the Electricity (Supply) Act of 1919 in such an emasculated form that its utility was greatly depreciated. It therefore became necessary to prepare a further measure and, in pursuance of this task, Kennedy submitted a report to the Electricity Commissioners in 1922 and many of his suggestions were embodied in the Electricity (Supply) Act of 1926 after he had given evidence before the Weir Committee a year earlier. One of the principal consequences of this second Act was the establishment of the Central Electricity Board, to which Kennedy and Donkin were, among others, appointed consulting engineers. In this position he was responsible for the preparation of the technical and financial information upon which the regional electricity schemes forming part of the necessary re-organisation were based. After the adoption of these schemes Kennedy's firm acted as consultants to the Central Electricity Board in Central and South Scotland, North West England and North Wales and South West England and South Wales.



The late Sir John Kennedy, O.B.E.

Between 1930 and 1934 Kennedy served as a member of the Fuel Research Board, but relinquished that position in the latter year on being appointed an Electricity Commissioner on the retirement of Mr. W. W. Lackie. Initially, he was the chief technical member of that body, being particularly concerned with questions of distribution. He acted as vice-chairman from 1938 to 1947 and was appointed chairman in the latter year, a position he held until the Commissioners were dissolved after the formation of the British Electricity Authority under the Electricity Act of 1947. In 1948, he was appointed a member of the Uganda Electricity Board but retired in 1952.

John Kennedy received a knighthood in 1943. He was elected an Associate Member of the Institution of Civil Engineers in 1905 and was transferred to the class of members in 1914. He had been a recipient of the Miller Prize of that body. His connection with the Institution of Electrical Engineers began in 1914 when he became a Member. He served on the Council from 1928 to 1931 and was then a vice-president for three years. He was elected president in 1935 and Honorary Member in 1947. Jointly with Miss. D. M. Noakes, he was awarded an Institution Premium in 1932 for a paper entitled "An Analysis of the Costs of Electricity Supply and Distribution in Great Britain." A memorial service is to be held at the Queen's Chapel of the Savoy, Savoy-street, London, W.C.2, at 12·15 p.m. on Thursday, September 16.

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We regret also to record the death of the following:

MR. CHARLES TURNBULL, at Gosforth, Northumberland on Monday, August 30, at the age of 84. He served his apprenticeship with C. A. Parsons and Company, Limited, Newcastle-on-Tyne and was appointed Borough Electrical Engineer of Tynemouth in 1899. He held this position until his retirement in 1935. He was elected an Associate Member of of the Institution of Electrical Engineers in 1900 and became a Member seven years later. He had served as chairman of the North East Coast Local Centre.

PERSONAL

MR. A. B. B. VALENTINE, M.Inst.T., formerly operating manager (railways) to the London Passenger Transport Board and latterly a member of the London Transport Executive, has been appointed a full-time member of the British Transport Commission. LIEUTENANT-COLONEL DONALD H. CAMERON OF LOCHIEL, T.D., who is particularly conversant with the circumstances and requirements of Scotland, has been appointed a part-time member of the Commission.

MR. J. E. BAGGULEY, M.I.Loco.E., has been appointed works manager to the Yorkshire Engine Co. Ltd. (branch of the United Steel Companies Ltd.), Sheffield. He was previously general production manager at the Distington Engineering Co. Ltd., Workington, Cumberland. MR. RUPERT LANCASTER, previously works manager, has been made general works manager to the Distington Engineering Co.

MR. J. S. LANGLANDS has been appointed by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, as assistant manager for Scotland. He was appointed managing director of the British General Electric Company (Canadian) Ltd., in 1948.

MR. CLIFFORD STURDY, B.A. (Cantab.), has been appointed assistant chief engineer (projects) to Davy and United Engineering Co. Ltd., Park Iron Works, Sheffield, 4.

MR. R. M. GRANT, B.Sc., M.I.E.E., has been appointed manager of the plant sales department of the British Thomson-Houston Co., Ltd., Rugby, in succession to MR. R. S. JONES, M.I.E.E., who has retired after 41 years' service with the company.

MR. C. W. J. TAFFS, M.Sc. (Eng.), M.I.Mech.E., has been appointed secretary to the Diesel Engine Users Association, 56 Victoria-street, London, S.W.1.

MR. DONALD MCDONALD, B.Sc., F.R.I.C., M.I.Chem.E., chairman of the executive committee of the board of Johnson, Matthey & Co., Ltd., Hatton-garden, London, E.C.1, since 1950, has retired after 44 years' service with the company.

MR. T. P. O'SULLIVAN, Ph.D. (Eng.) (Lond.), M.I.C.E., consulting engineer, has opened a London office at 249 Waldegrave-road, Twickenham, Middlesex. (Telephone: POPesgrove 2692.)

MR. W. L. DRUMMOND has resigned his position as vehicle sales manager to Sentinel (Shrewsbury) Ltd., in order to take up an appointment with another company. He is succeeded by MR. H. W. SANSUM, who, as sales and service manager of the company's vehicle division, will combine responsibility for vehicle sales with his duties as general service manager.

MR. ALFRED WALTER WELTON, A.S.A.A., has been appointed a director of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2. He is also a director of Mullard Overseas Ltd. and Mullard Wireless (Near East) Ltd.

MR. A. S. TAYLOR, at one time production manager to the Universal Engineering Co., Ltd., has joined the Wallace Attwood Co., management specialists, Chantry House, Eccleston-street, London, S.W.1, as a consultant.

GROUP CAPTAIN R. C. RICHMOND, R.A.F. (ret.), has been appointed to the London office of Marconi's Wireless Telegraph Co. Ltd., at Marconi House, Strand, W.C.2, for duties in connection with the company's aeronautical radio business.

MR. G. H. M. HOUSTON, B.Sc., A.M.I.E.E., has joined Brookhirst Switchgear, Ltd., Northgate Works, Chester, as manager of their power applications branch, which has been established to develop motor-control gear for power-station auxiliaries. Mr. Houston's office will be at Universal House, Buckingham Palace-road, London, S.W.1.

MR. JOHN R. S. HALFORD has been appointed export sales manager to I.T.D., Ltd., 95/99 Ladbrokegrove, London, W.11, in succession to MR. R. J. L. FISH.

The College of Aeronautics, Cranfield, Bedfordshire, announces that MR. G. E. SMITH, Palmers Green, London, N.13, has been awarded the Perring Scholarship for the two-year course commencing next month; and that MR. M. E. FILBY, Brockworth, Gloucestershire, has been awarded the English Electric Research Fellowship in Aeronautics for the academic year 1954-55.

The Regent Oil Co. Ltd., 117 Park-street, London, W.1, announces that MR. F. E. W. LAURIE has retired from his position as manager at the company's Western branch and will take up duties in the general sales division at the head office. MR. H. J. TANNER has been appointed manager of the Western branch and is succeeded, in his previous position as manager of the North-Western branch, by MR. A. B. MUM-

FORD. MR. KENNETH POTTER has been appointed manager of the industrial and automotive lubricants department in succession to MR. W. H. GOODHIND, who has left the firm to become manager of the supply and distribution department of the Calex Trading and Transport Co., Ltd., Thames House, Millbank, London, S.W.1. MR. R. D. CRANFIELD, formerly divisional manager, South Wales, with the Regent Oil Co., has succeeded Mr. Mumford as divisional manager, Avonmouth. MR. S. H. TROTT, formerly divisional manager, Exeter, has been made divisional manager at Liverpool. MR. J. FORSHAW, previously on the sales staff of the North-Western branch, has been made divisional manager at Exeter. MR. J. H. WILLIAMS has become divisional manager, South Wales Division.

MR. ARCHIBALD CAMPBELL, C.B.E., M.I.Mech.E., of the chief mechanical engineer's department of the Crown Agents for the Colonies, has been elected President of the Institution of Locomotive Engineers for the session 1954–1955, and will be inducted at the meeting of the Institution on September 22. The headquarters of the Institution are at 28 Victoria-street, London, S.W.1.

* * *

BUSINESS CHANGES

The JOHN THOMPSON GROUP OF COMPANIES are moving their Manchester and North Midlands branch office to Sunlight House (sixth floor), Quay-street, Manchester, 3 (Telephone: Deansgate 6151/2) on October 1.

ENTHOVEN SOLDERS LTD., Enthoven House, 89 Upper Thames-street, London, E.C.4 (Telephone: MANsion House 4533), have been appointed sole concessionaries by SCOPE LABORATORIES, Melbourne, Australia, for their 6-second Superspeed soldering iron. Inquiries should be addressed to Enthoven's industrial equipment division. This iron was described in our issue of July 23, page 120.

THE BRUSH GROUP, LTD., announce that they will operate in Venezuela in future under the title BRUSH GROUP DE VENEZUELA SOCIEDADE ANONIMA, Apartado 5159 este, Carácas, Venezuela. MR. C. P. COURT, previously on the staff of the Group's Venezuelan agents, has been appointed director and manager of the new organisation, which will represent the Brush Electrical Engineering Co., Ltd., Petters, Ltd., J. and H. McLaren, Ltd., the National Gas and Oil Engine Co., Ltd., and Mirrlees, Bickerton and Day Ltd. The new company will also represent Enfield Cables, Ltd., in Venezuela.

DERBYSHIRE STONE LTD., Bank House, Matlock, Derbyshire, have inaugurated a service to provide British stone-quarrying experience for the development of suitable quarry sites in the Middle East. At the request of governmental or industrial organisations, the company's staff will investigate and survey suitable sites, and make recommendations for their design and layout, and for the purchase and erection of the necessary plant and equipment.

THORN ELECTRICAL INDUSTRIES LTD., 105-109 Judd-street, London, W.C.1, and SYLVANIA ELECTRIC PRODUCTS INC., New York, have formed a jointly-owned subsidiary, known as SYLVANIA-THORN COLOUR LABORATORIES LTD., to undertake research and development work on colour television, including the design of cathode-ray tubes, and to investigate problems connected with the application of semi-conductors to electronics. MR. B. C. FLEMING-WILLIAMS, B.Sc., has been appointed general manager of the new company, the address of which is at Judd-street, W.C.1.

J. M. VOITH, G.M.B.H., Heidenheim/Brenz, Germany, have concluded an agreement with BROWN BROTHERS & CO., LTD., Rosebank Iron Works, Edinburgh 7, by which the latter firm will manufacture, under licence, the Voith-Schneider propeller and control equipment, for distribution within the British Commonwealth. CAPTAIN E. C. GOLDSWORTHY, Estate Buildings, South-road, Weybridge, who has represented the makers of this propeller in the British Commonwealth hitherto, will continue to act in a sales and liaison capacity.

G. M. GIANNINI & CO., INC., New York, manufacturers of scientific instruments and control equipment, have formed an affiliated organisation in Britain, named GIANNINI LTD., to negotiate licences for the manufacture of equipment to Giannini designs in the British Commonwealth, other than Canada. The directors of the new company are MR. BERNARD SUTTON, and MR. CHRISTOPHER DYKES, M.A., M.S., A.F.R.Ae.S., 31 Pembroke-gardens, London, W.8. (Telephone: WEStern 9493), to whom inquiries should be addressed.

EFFECT OF NEW MATERIALS ON ENGINEERING PROGRESS

LOGICAL DEVELOPMENTS GIVE INCREASING SCOPE

Giving the presidential address* to Section G of the British Association, Dr. Willis Jackson said that he had chosen as his subject the development of engineering during the past half century particularly with regard to the effect of new materials. All earlier discoveries, such as bronze and steel, had been more or less accidental, but now the stage had been reached when materials were being evolved logically from "the intellectual edifice called natural science." Being an electrical engineer, he proposed to draw examples from that field.

POWER CABLES

The first example Dr. Jackson took was that of power transmission. The first insulating material used was gutta percha which was quite satisfactory for the pressures of 100 volts then in use. The next step forward was Ferranti's 10,000-volt cable from Deptford to Bond-street for which paper impregnated with ozokerite wax was used. Development of the impregnated paper technique had now made possible the construction of cables for 275,000 volts and above. The oil filling of cables had reduced losses and allowed the operating temperature to be doubled.

Submarine cables continued to use gutta percha in a more refined form until, in 1933, polyethylene was produced. In addition to having suitable qualities for under-water work, this material showed remarkably low electrical losses up to very high frequencies, and it played a vital part in the early development of radar. Dr. Jackson said that his scant references to the uses of polyethylene only touched the fringe of the great progress in the production of the materials called plastics, the present range of which was enormous.

The author then turned to consider the electrical transformer, invented in the early 1830's by Faraday. In the large power transformer, which might work at up to 350,000 volts, efficiencies of 99·4 per cent. could be obtained. Even this apparently small loss, however, gave rise to cooling problems. Since it was mainly caused by magnetic losses in the core, new materials for the construction of the latter were continually being sought. Mild steel laminations were followed by silicon steel, in varying degrees of purity, and now advantage was being taken of the directional properties of ferromagnetic crystals by carefully controlled cold-rolling techniques. In connection with high-frequency transformers, Dr. Jackson showed how performance had been improved by first the development of nickel iron and other alloys in sheet form and then their use as compressed powders. Latterly, iron oxide (Fe_3O_4) had been used and the class of materials known as Ferrites was being developed. These last could be used in sheet form.

TRANSISTORS

Dr. Jackson next proceeded to describe a different way in which progress could occur – by the discovery, and recognition of the potentialities, of some special property of a material which led to the evolution of a new engineering technique. As an example he took the development of the germanium crystal triode, known as the transistor. This was a logical development from the silicon crystal, used in the early days of radio, which during the war was used widely in apparatus using centimeter waves – at first only as a stop gap till a thermionic valve could be developed, and later in its own right. While this development work showed that silicon was excellent at high frequencies, it also revealed that germanium was superior as a rectifier. The germanium diode followed, and then, in 1948, the germanium triode was produced. Two types were now being made, known as the point-contact and junction types according to their method of construction. Each had its particular uses, and Dr. Jackson referred back to the submarine-cable, in which the junction type could be used as repeaters owing to their small power requirements and small size. Other uses were in guided missiles and computors.

NUCLEAR FISSION

In quite a different field, a new engineering technique had emerged from the development of a material, which, said Dr. Jackson, had been of insignificant engineering importance less than fifteen years ago. This was isotope 235 of uranium from which energy could be obtained by fission, exploiting the difference in mass between the original atom and the fission products which appeared as free kinetic energy. This had a total magnitude of about 200 million electron volts per fission. As an average of 2·5 neutrons were produced each time, 1·5 were available for external use for 1 must go to produce another fission if the action was to continue.

The rods of uranium were surrounded by medium known as the moderator having two essential requirements. First, it must slow down the neutrons to the speed best suited for capture, and second it must have atoms of low weight and low absorption characteristics to avoid unnecessary loss in the process. Graphite, light water, and heavy water were three materials used up to date. Of these, heavy water was the best, but was also the most expensive and did not provide support for the rods, while light water was intrinsically the cheapest, but similarly did not provide support and also required enriched uranium due to its neutron losses. Graphite did provide support but required a larger bulk.

COOLING MEDIA

Dr. Jackson said that each gram of U_{235} produced 22,000 kilowatt hours of energy which had to be removed by a cooling medium. For this, helium, carbon dioxide, light water, heavy water, and liquid sodium or sodium-potassium alloys had been suggested. The new plant in Cumberland would use carbon dioxide under pressure. But, he said, the most difficult of all problems was the material to encase the fuel elements. Aluminium and magnesium had been tried, but both had low melting points and inadequate mechanical properties. Attention was now being paid to beryllium and zirconium.

In conclusion, Dr. Jackson said his review had of necessity been brief and incomplete. But he hoped he had said sufficient to illustrate the intricate way in which engineering advances were linked with the development of new materials and techniques, which in turn led to further study and a further chance of advance.

* "The Effect of New Materials on Engineering Progress." Delivered before Section G of the British Association on Friday, September 3.

THE SCOTTISH INDUSTRIES EXHIBITION

A WIDE RANGE OF PRODUCTS AT KELVIN HALL

The many stands at the Scottish Industries exhibition at Kelvin Hall, Glasgow, give an impression of the variety of industries and crafts that are now being carried on in Scotland. The items which are being exhibited range from traditional silver-ware from Iona and homespun tweeds to the very latest devices in electronics and in heavy industries. An article on the development of engineering industries in Scotland appeared in our issue of August 27, page 264.

The exhibition was opened on September 2 by Her Majesty Queen Elizabeth the Queen Mother, and among the stands she visited was that of Rolls-Royce Limited who were showing an Avon engine similar to the type fitted in Comet II aircraft, and also sectioned Merlin and Griffon engines. The firm now have four factories in Scotland employing some 12,500 people.

COAL-BURNING GAS TURBINE

The North British Locomotive Company, Limited, Springburn, Glasgow, were exhibiting one of their 100-h.p. Diesel-engined mine locomotives (ENGINEERING, vol. 171, page 720, 1951) and also a model of a coal-burning gas-turbine locomotive that is now being designed in conjunction with C. A. Parsons and Company, Limited, Newcastle-on-Tyne. This will be an experimental prototype intended to give all the advantages of the gas-turbine without using either fuel oil or water. It is claimed that this new locomotive will only use half the coal consumed by a steam locomotive doing the same work and will have a maximum efficiency of 19 per cent. An exhaust heating cycle will be used in which air is the working fluid. The wheel formation chosen is A1A-A1A and the locomotive will be rated at 1,750 h.p. with a tractive effort (for freight traffic) of 45,000 lb. at starting. Further reference to this will be found elsewhere in this issue.

A piece of test equipment exhibited by Ferranti Limited, Hollinwood, Lancashire (who have a research centre at Edinburgh) is an integrated micro-wave test " bench " for use in the 3-cm. band (9,000 to 10,000 megacycles). This is illustrated in Fig. 1. It can be used to make measurements of impedence, attenuation, insertion losses and also of voltage standing-wave ratios. These measurements can be carried out on almost all components used in the frequency band, including aerials. Three Klystrons supply the input, one of them having a dummy load which can be removed for such work as super-heterodyne mixing tests. The apparatus enables complex circuits to be achieved in a compact unit. Among other items on the stand was an exhibition of Xerography, a method of electrical photography requiring neither wet chemicals nor dark room.

Among the exhibits on the stand of the Caledonian Tractor and Equipment Company Limited, Rigby-street, Glasgow, E.1, was the " Jay-Dee " attachment for drilling and tapping. This is designed to fit any lathe or drilling machine and will only transmit torques up to a fixed value. The collet for the tool is gripped in the body of the device by a ring which slides axially and which is held in the " locked " position by gravity when the device is used on a vertical-spindle machine. Different collets are available to cover a very wide range of drill sizes. The torque-limiting mechanism consists of six rubber-backed dogs which engage in slots on the collet shank and are held in place by a knurled ring. Rotating this ring alters the inward pressure on the dogs and therefore the torque at which they will be forced out of the collet slots. This device has reduced the number of drill and tap breakages due to high torques, especially when blind holes are being drilled.

Cockburns Limited, Cardonald, Glasgow, S.W.1, have as their chief exhibit a combined main steam control unit of the type supplied for tanker service to operate at steam pressures of 900 lb. per square inch and temperatures of 900 deg. F. This unit comprises: ahead turbine regulating valve; astern turbine regulating valve; astern turbine guarding valve; turbine emergency valve; and strainer. Also on the stand was an electrically-operated parallel-slide valve developed for use in power stations. The electric actuator for this is made by the Rotork Engineering Company, Limited, Kingswood, Bristol, and consists of a motor-driven gear box complete with switching apparatus and provision for remote indication. A mechanism is incorporated which will supply a high torque momentarily to unseat a valve that has become stuck. A number of standard boiler fittings are also on show to indicate the range available.

Nicol and Andrew, Limited, 236 West George-street, Glasgow, C.2, are showing examples of their " Master " grinding and superfinishing equipment. This has been developed during the last year or so for the express purpose of grinding crankpins and bearings of ships' engines without having to remove the engines from the vessel. The internal equipment is also suitable for grinding cylinder bores. The maximum sizes at present made are for internal diameters of 36 in. and external diameter of 47 in. Fig. 2, below, shows the complete equipment for internal grinding using the " Portrider " grinding head, which is built up from two standard heads to give a grinding contact long enough to pass over the ports.

The grinding stones are set in carriers which

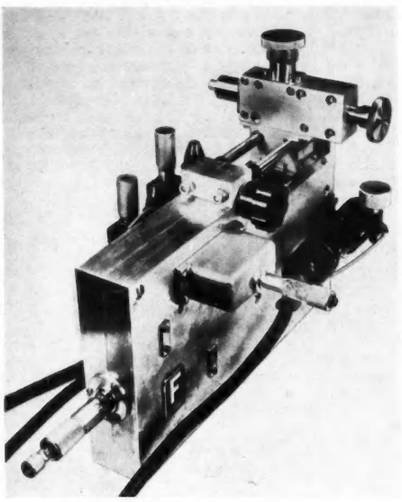

Fig. 1 Micro-wave test bench for making measurements on apparatus used in the 3-cm. band (Ferranti Ltd.).

can be extended outwards by a mechanism which moves all four equally. There is a spanner attachment at the top of the head which acts through reduction gearing to effect the movement; an automatic lock holds the arms in position after the adjustment has been made. Axial movement of the grinding head is brought about by sliding the " Gearopower " driving unit along the rails which can be seen in Fig. 2. Adjustable stops can be set to give the required amount of movement and to prevent the head emerging too far beyond the workpiece. A range of speeds are available from a gearbox in the head.

The head used for external grinding is shown in Fig. 3. This is driven by a belt which runs in the groove on the periphery of the head. In this case, axial movement of the head is obtained by moving the belt along the cylindrical driving pulley with the guide bar provided for the purpose. This guide bar also carries a jockey pulley which keeps the belt tension correct. The two halves of the grinding head are clamped together round the work, and the stones are tightened by the hand adjustment, which can

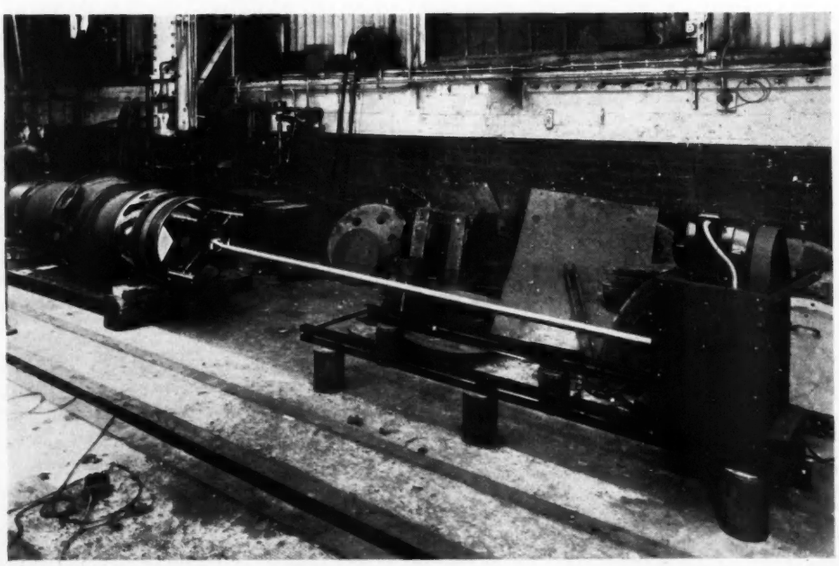

Fig. 2 Portable internal grinding equipment for large cylinders or bearings (Nicol and Andrew, Ltd.).

be seen on each side. Different grades of stone can be fitted to both the internal and external heads, as required for the work in hand. Accuracies within 0·0015 in. can be obtained with a surface finish of about 15 micro-inches. The equipment is comparatively light and is easily transportable.

On the stand of Archibald Low and Sons, Limited, Partick, Glasgow, W.1, there is a wide range of ships' galley equipment, both steam and electrically heated, and also an example of their hydraulic lifting gear designed for ships' skylights. This gear comprises simply a hydraulic cylinder and plunger, fitted at the skylight, and a small hand pump which can be placed at any convenient spot. With this, all mechanical linkage from the position of operation to the skylight is eliminated and the cylinders can be controlled either singly or in gangs by suitable valve arrangements. Many ships recently built have been fitted with this apparatus – in particular for the engine-room skylight, which may be some considerable height above the floor.

LONG-LIFE BATTERY

A storage battery which is claimed to have an extra long life, is exhibited by James McGrath, Limited, Main-road, Elderslie, Renfrewshire. In this, the plate separator is a glass-wool mat backed by a mineral insulating material. The separator is porous and does not require the use of any special wetting agent initially. Nor does it become impervious to acid if the battery is allowed to dry out. Insulation is excellent and resistance to current is very low.

Kelvin and Hughes (Industrial), Limited, 110 Bothwell-street, Glasgow, C.2, are exhibiting several items of their manufacture. One of these is an Ampro recording projector for 16-mm. films. This machine is an optical/magnetic version with full studio facilities. It is capable of remote-control recording, single-frame projection and forward and reverse operation.

Machinery for sawing and shaping stone is being shown by the Anderson-Grice Company, Limited, Taymouth Engineering Works, Carnoustie. Diamond-impregnated saws and drill bits are among the exhibits, some of the latter being used as core bits for geological drilling. The firm also manufactures electric cranes, and are displaying a model of a stiff-legged derrick. This is made of unit construction so that it can be moved from one site to another without complete dismantling.

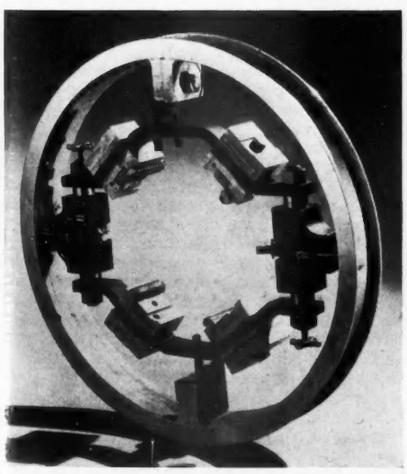

Fig. 3 External grinding head developed for grinding ships' crankshafts and crankpins in situ (Nicol and Andrew, Ltd.).

BRITISH ASSOCIATION MEETING

EFFICIENT STEAM GENERATION: USE OF FIREDAMP FROM COLLIERIES: VEHICLES AND ROAD ACCIDENTS

The annual meeting of the British Association for the Advancement of Science, held this year in Oxford and concluded on Wednesday, September 8, was the 116th in the history of the Association and the sixth to be held in the County Town of Oxfordshire. Founded in 1831, the Association selected Oxford for its meeting-place in the following year and has visited the same centre of learning and industry on four other occasions prior to this year's meeting, namely, in 1847, 1860, 1894 and 1926. The Association has itself been described as a "peripatetic university" and this may give it a particular affinity for university cities and towns. Certainly its meetings in such centres have been notably successful and this tradition has been fully maintained at Oxford this year, where Town and Gown have spared no effort to welcome the members.

INAUGURAL MEETING

The members first assembled in the Sheldonian Theatre for the inaugural meeting on the evening of Wednesday, September 1, the meeting being preceded by a Convocation of the University of Oxford, when the Vice-Chancellor, Sir Maurice Bowra, M.A., D.Litt., conferred the Honorary Degree of Doctor of Science on Sir Ben Lockspeiser, K.C.B., F.R.S., Sir John Lennard Jones, K.B.E., F.R.S., and Sir Harold Spencer Jones, F.R.S. The members of the Association were then welcomed by the Vice-Chancellor and by the Mayor of the City, Alderman W. R. Gowers, M.A., on behalf of the University and the City, respectively, after which Dr. E. D. Adrian, O.M., P.R.S., this year's President of the Association, delivered his address entitled "Science and Human Nature." The proceedings in the Sheldonian were relayed by television to the Town Hall, where an overflow meeting was held. We commented on Dr. Adrian's Presidential Address in a leading article in last week's issue. Sir Edward Appleton, G.B.E., K.C.B., F.R.S., thanked the President for his address, remarking that he had dismissed in a brief phrase his own contribution to the subject. Sir Edward, in conclusion, thanked the President for the thoughts he had put before the meeting and expressed admiration for his acknowledgement of the scientific kinship of all serious students of human phenomena. The President, in acknowledging the vote of thanks, welcomed the overseas guests and expressed thanks on the part of the Association to the Vice-Chancellor of the University and to the Mayor of Oxford for having given the members the privilege of holding their meetings in such inspiring surroundings.

The reception room and the administration offices of the Association were in Rhodes House, South Parks-road, and the various colleges and schools of the University were made available for the accommodation of the 13 sections into which the work is divided. Several sections, including Section G (Engineering), with which we are mainly concerned, transacted their business in the University Museum building. The sectional meetings commenced on the morning of Thursday, September 2. As is now usual, most of the meetings of Section G were divided into two sessions, A and B, held simultaneously in adjacent rooms to enable the heavy programme to be completed in the time available.

EFFICIENT INDUSTRIAL STEAM GENERATION

The first item in the programme of Section G was a paper by Mr. D. C. Gunn, of the British Coal Utilisation Research Association, entitled "Efficient Industrial Steam Generation," which was read before Session A. The paper, which is reprinted elsewhere in this issue, was read by the author, the chair being taken by Lord Dudley Gordon.

The first speaker in the discussion was Mr. J. Rosen, who inquired whether the type and quality of boilers in use to-day were responsible to any extent for the lack of efficiency in fuel utilisation. He also asked if the Government were taking any steps to encourage the replacement of old boilers. Mr. Gunn replied that, to his knowledge, no inefficient boilers were being made at the present time by industrial firms and the majority of boilers currently employed, including Lancashire boilers, were capable of efficiencies of over 80 per cent. As indicated in the paper, the cause of inefficiency was largely faulty boiler operation and control, for which operators and managements were principally responsible. Mr. Gunn also reported that training schemes and special qualifications were being instituted for boiler operators. Mr. A. A. Haigh asked if fuel size played any part in boiler efficiency and, if so, whether firing-control mechanisms taking this factor into account had been devised. In his reply, Mr. Gunn said that fuel size and quality were certainly important considerations but present forms of automatic controllers were not designed to make allowance for these factors. The justification for using automatic boiler control was based on the assumption that the fuel supplied would be consistent in size and quality.

Commenting that natural-draught boilers had been the main subject of the paper, Mr. R. Smallwood inquired whether forced draught might profitably be employed. Mr. Gunn said that it did not matter whether air was drawn or blown through a boiler plant; the work described in the paper had been carried out in all operating conditions and no correlation between draught and boiler exit temperatures had been obtained. An important consideration in the design of boilers with small smoke tubes was the advantage to be gained in steam production by the use of an induced-draught fan. Mr. Gunn believed that the power consumed by the fan was entirely outweighed by the reduced exit temperature and the corresponding increase in efficiency, which was approximately 6 per cent.

The final speaker in the discussion, Dr. J. H. Jones, Chief Scientist to the Northern Division of the National Coal Board, asked for an estimate of the efficiency at which an operator should aim when firing a Lancashire boiler with untreated smalls, ⅛ in. to 0 in. in size, and having an ash content ranging from 15 to 35 per cent. The load on the plant might be variable and the boiler was hand fired.

In response, Mr. Gunn drew attention to Fig. 2 in the paper, which showed the effect of excess air and heat-transfer rate on boiler efficiency. He assumed the heat-transfer rate in the given case to be 7,000 B.Th.U. per square foot per hour and the coal employed to be ⅛ in. in size. If the boiler were hand fired, the operator would probably be unable to achieve a proportion of carbon dioxide higher than 6·5 per cent. and this would limit the boiler efficiency to 50 per cent. If, however, a modern automatic stoker handling a wide range of small fuels were used, and he strongly recommended this practice, an average of 10 per cent. carbon dioxide might be expected. In this case a boiler efficiency of 65 per cent. would be a reasonable target.

In summing up, the chairman emphasised the importance of improved boiler efficiencies in the national interest; another aspect of the problem, he said, was the reduction in atmospheric pollution which would follow a rise in boiler operating efficiency.

USE OF FIREDAMP FROM COLLIERIES

The second paper dealt with in Session A on Thursday morning was one by Dr. J. H. Jones and Mr. J. G. Bromilow, of the National Coal

Board. The paper indicated the manner in which the hazards of "Coal mining had been reduced by firedamp drainage and the production of coal thereby increased." It also illustrated the use of the gas as a fuel for boilers and internal-combustion engines, and also, after suitable treatment, how it could be distributed through mains as a public utility service.

An account was given of the occurrence of firedamp in mines and it was stated that the gas discharged ranged from negligible quantities to rates of the order of 4,000 cub. ft. per ton of coal mined. The general principles of methane drainage, including calorific value and quantitative measuring devices, were explained and such safety precautions as fire traps and shut-down systems were dealt with. Special reference was made to the methods employed at the Haig Pit, Whitehaven, Cumberland, where hitherto it had been necessary to circulate ten tons of air per ton of coal mined and where firedamp drainage had enabled an increase in coal putput of 50 per cent. to be made. Moreover, the supply of methane fuel for firing the colliery boilers had released 300 tons of washed coal a week for other purposes. Other pits referred to included the Old Boston Colliery, Lancashire, where an automatic boiler plant had been installed, and the Point of Ayr Colliery, North Wales, where dual-fuel Diesel engines are to operate on methane gas, and where re-forming plant and gas producers have been installed to serve in conjunction with the gas grid to supplement the domestic supply.

In the discussion that followed the reading of the paper, the first speaker was Mr. H. K. Sankey, who inquired if the authors had experienced any difficulties due to dust in the extracted gas, with respect to explosions or maintenance of plant. Mr. Bromilow replied that no trouble of this kind had been encountered. In response to a question by Lord Dudley Gordon, regarding the use of dust extractors, Mr. Bromilow replied that none was in fact employed but that, at a North Wales colliery where the gas boreholes had been driven downwards, the gas contained considerable quantities of water and the salts dissolved in it were carried to the surface. The normal upward-driven boreholes, however, were fairly dry and the gas they carried contained neither dust nor chemical salts.

In asking if the authors had developed a reliable flame trap, Dr. F. D. Bosanquet remarked on the tendency to blow back, such that the flame front retreated through the pipeline and might even give rise to detonation. Dr. Jones replied that this subject had been extensively studied and that the velocity of flame propagation in methane was so low that almost any form of flame trap was adequate. If, however, as much as 2 per cent. of hydrogen were present the danger would be considerably increased. Since the mixture now extracted consisted of air and methane only, any conducting material was capable of removing the heat, and in some Saar collieries static water tanks filled with pebbles had been employed.

In response to a question by Mr. H. Young concerning the possibility of increasing the suction of the extracting plant in order to lower the proportion of methane and provide a gas for direct use in turbines, Dr. Jones replied that the main object was to remove methane from the pit for considerations of safety, and that as suction increased the proportion of methane fell. The proportion of methane extracted initially had been 85 per cent. and they had increased suction until now the concentration was only 65 per cent.; the benefit to be gained by increasing suction further was negligible.

The chairman, in thanking the authors for their account of a remarkable achievement, said that if, as the authors had estimated, the thermal value of the methane that could be drained from collieries in this country was equivalent to about 8,000,000 tons of coal per annum when the system was fully developed, it would represent a very considerable contribution to the solution of the fuel problem.

VEHICLE CHARACTERISTICS AND ROAD ACCIDENTS

The chair at Session B on Thursday morning was taken by the President of the Section, Dr. Willis Jackson, F.R.S., and the first paper taken was entitled "The Relationship Between Vehicle Characteristics and Road Accidents." It was presented by Mr. G. Grime, O.B.E., M.Sc., of the Traffic Safety Division of the Road Research Laboratory at the Department of Scientific and Industrial Research. The paper is published elsewhere in this issue.

Mr. L. Bainbridge-Bell, who opened the discussion, said that for brake testing he had a tester permanently fitted to his car. A useful device employed before the war consisted of a rectangular empty box which was stood up on the floor of the car one way. The brakes were put on hard, and the box either fell over or did not; it was then tried in the two other directions, and so three stages of deceleration could be tested.

Mr. A. C. Hartley, C.B.E., read a contribution which had been sent in by Wing Commander Cave-Browne-Cave, who was prevented by illness from attending the meeting. Wing-Commander Cave-Browne-Cave pointed out that misty windows greatly restricted the driver's view and greatly increased the risk of accident, especially when rain, darkness and other conditions also made driving difficult. The demisters fitted in some cars did improve the condition of some parts of the windscreen, but had no effect upon the side and rear windows. The mist was formed by the moisture given off by the breath and damp clothing of the occupants of the car. The warmer the atmosphere of the car, the greater would be its moisture content and therefore the greater the deposit of mist. Car heaters which raised the saloon temperature without introducing a large quantity of fresh air increased the evaporation from the passengers and caused worse misting and a more sleepy atmosphere.

Once the exact nature of the danger was recognised the cure was simple. The quantity of air passed through must be sufficient to carry away the moisture without allowing the humidity to deposit mist on the cold windows or to produce a sleepy atmosphere. By some re-arrangement of the cooling system the whole of the waste heat in the cooling water of the engine could, during winter, be passed through the saloon in a large quantity of air which completely prevented misty windows. The heat available was sufficient to maintain a temperature some 15 deg. F. above that of the outside air. The system was tried first on a double-decker 'bus of Southampton Corporation. It had been in use for five years and the Transport Engineer reported that they never had misty windows and could maintain a saloon temperature of 15 deg. F. above that of the outside air, which was ample.

Good manners with a patient state of mind were factors which contributed greatly to safe driving. The signal made in acknowledgment of a careful or generous act by another driver or a pedestrian tended to encourage these factors in the giver of the signal as well as in the recipient. It, therefore, made an important contribution to safety as well as to general good manners. Unfortunately, this "Thank you" signal given by hand was seldom effectively visible even by day and never by night. A single small lamp of blue or some other distinctive colour mounted above the centre of the windscreen might be made visible all round. Operating this light by a press-button the driver could give his "Thank you" with no more trouble than he operated his horn.

Mr. Grime replied that he was in complete agreement with the views expressed by Wing-Commander Cave-Browne-Cave.

Dr. E. A. Watson said insufficient use was being made of the offside mirror on cars. The standard car had a centre mirror sometimes at the top and sometimes at the bottom of the windscreen; it was often too small and certainly produced a blind spot. His own experience after fitting and using an offside wing mirror was that it was far more help in driving than was the normal central mirror. With regard to the question of visibility through the rear window of the car, this window certainly had a tendency to mist over. Although a properly designed heating system might stop the misting the car he had been driving had a system whereby the heating was done by fresh air brought from the front of the radiator; this was all right after driving for some miles, but during the initial period when the engine was warming up in the winter and the windows were nearly closed, the rear window misted over very badly. There was a tendency now to put demisters on the rear window.

The question of headlamps was a very difficult one, and he was sorry to see the curve in Fig. 13, which indicated that the British double-dipped headlamp was showing up much worse than the American headlamp, even in a State where there was no inspection, because the British headlamp was made to conform to the American standard, and if it was equally well maintained and adjusted it should give the same results. It was clear that the headlamps in this country were either not initially set so well or not maintained and adjusted, although it was difficult to see how a flush-fitting headlamp could get out of adjustment. It would appear that the car manufacturer was to blame. There was also the problem of old headlamps. In a large number of cars now on the road, the headlamps had been fitted 15 years ago, and although the drivers replaced the bulbs when necessary and probably had the rest of the car sprayed, it never occurred to them that the reflectors had become badly tarnished. The new lamps were hermetically sealed, and it was a common practice to use an aluminium film, which would not tarnish.

Mr. Grime, in reply, said it would be useful if manufacturers regarded the offside mirror as a feature which ought to be put on the car before it was sold. Moreover, much could be done to improve the optical characteristics of mirrors. Generally speaking there was one type of mirror which was supposed to be fitted anywhere on the car, whereas a little thought would show that the curvature should be different according to the position. As regards headlamps, the conclusion was that they were not being properly set to begin with; the newer lamps were better aimed than the old ones, but were not yet aimed well enough. Also, he would reinforce Dr. Watson's plea that old headlamps should be replaced: anyone who replaced them with really modern headlamps would find it very well worth while because it reduced dazzle and enabled the driver to see where he was going.

Mr. H. Murrell said his experience with the modern headlamp was that every time the bulb was changed the focus of the lamp was altered, which looked as though the lamp-manufacturing methods were not yet sufficiently accurate to place the filament always in the correct position.

Mr. Grime, in reply, said with the present design the lamp had to be re-aimed whenever a bulb was changed, which was quite a simple matter since adjusting screws were now provided. The modern theory and practice in headlamp design had undoubtedly changed for the better. Before the war narrow pencil beams were used, which did enable the driver to see quite a long way, but since the war the importance of making the beam comfortable to drive with had been discovered. Modern headlamps put much more light on the road near the car and also on the right-hand side of the car, and therefore the intensity of the light which was directed towards an oncoming driver was greater than it used to be, although the amount of dazzle was less. The question of being dazzled or not depended not only upon the light coming into the driver's eyes but also upon his own headlamps, and in tests for assessing comfort in driving it was usually found that the modern type of headlamp was better than the old.

This concluded the discussion on the paper.

To be continued

THE ECLIPSE OF THE ENGINEER IN MANAGEMENT*

By Bosworth Monck

Most of us know that our standard of life depends upon our export trade: the exhortations of governments, the shrinkage of the individual purse and of the national import programme have made this fact familiar – though what each of us should do about it is less clear. The emphasis since 1945 on the crucial importance of the export trade to our economic affairs is partly due to a number of causes beyond our control, either as a nation or as individuals. The best known may be worthwhile mentioning again: the interest on overseas investments no longer accounts for so large a proportion of our total national credits simply because part of the investments were realised for war purposes, while the interest on the remainder is no longer worth what it was. Similarly, a financial consequence of the war was a long run of " sterling balances " – incurred for military purposes – which have had to be worked off by peacetime labours. Altogether in 1938 " invisible earnings " financed 28 per cent. of our imports (8 per cent. was financed by a deficit) while in 1952 the figure had fallen to about 7 per cent. in terms of imports only four-fifths of what we had had in 1938. Correspondingly, the proportion of our imports for which we paid by exports – " visible earnings " – had risen from 56 per cent. in 1938 to 75 out of a total of 82, the latter figure corresponding to our 1952 imports as a proportion of 1938.†

The engineering industry contributes not only to our exports but to our domestic consumption and comfort, and provides the bootstraps by which we must pull ourselves out of our difficulties, through the re-equipment and modernisation of plant in most other industries as well as its own. Its importance is enhanced as, in the markets of the world where we must shop, two of our other national assets are no longer worth what they were even in the inter-war years: coal, greatest of our natural resources, has been increasingly replaced by oil as the international currency for power; while textiles, the foundation stone of our commanding position in Nineteenth Century world trade, are increasingly made elsewhere and, moreover, have an import content of about 28 per cent. as against 7 per cent. for our metal and engineering output.‡ Thus in 1952, export of raw materials amounted to only 4 per cent. of the total, textiles to 10 per cent. and engineering products to no less than 47·5 per cent.§ In this situation the strength of the British engineering industry is of decisive importance and its strength in turn is bound up with the ability of our engineers, the use that is made of them, and the level of their skill and experience. The engineering industry I examine here includes, for example, the makers of all forms of transport equipment and electrical goods, machine tools and other manufacturing equipment and components for all of them, but excludes chemicals and oil, steelmaking and building, except structural and civil engineering.

The favourable terms of trade in 1953, leading to a favourable balance of payments and rising gold and dollar reserves in the sterling area, have all contributed to a recent sense of tranquillity here about our economic well-being, in striking contrast to the world political scene. Similarly, because of the growth of our industrial exports, many believe that all is now well in that quarter. But the hard fact is that from 1948 to 1951 the United Kingdom's contribution to world trade in manufactures grew more rapidly than the volume of world trade, while in the second half of 1952 this favourable trend was reversed. Moreover, the United Kingdom's share in world trade of manufactures fell from 23 per cent. in 1950 to about 19 per cent. in 1952,* just about the pre-war figure. Thus any check in the expansion of world trade – let alone any contraction – will hit our standard of living most painfully unless we can substitute British exports for other exports, a feat we must needs perform against severe competition.

DECLINE IN BRITISH SHARE OF WORLD TRADE

To illustrate the way our engineering products have been losing the world's favour, Table I has been prepared.† It shows the relative importance of eleven countries in the world market for manufactured goods, and distinguishes between total contribution to world trade, and metal goods, most of which are products of the engineering industry as I use the term.

This table clearly shows that the United Kingdom held the leading position in world trade in manufactured goods until 1937, although our proportion had been falling steadily from 1899 until then. In terms of world trade in engineering products the United Kingdom had lost its leading position to Germany by 1913, whereas by 1929 both the United States and Germany had surpassed us. In engineering products, the proportion of world trade secured by the United States was roughly the same in 1952 as in 1929. Finally, the figures for 1950 and 1952 for engineering products show that the United Kingdom's position is relatively worse in the latter year than the former, having lost ground to Germany, Belgium and Canada, while the United States has about retained her share.

The great question which faces us is whether the changes that have already occurred or which may befall in the future are due to forces beyond or within our control. It is perhaps human nature to claim the former when the changes are for the worse, and the latter when they are for the better. At present, therefore, leading industrialists in their annual speeches as company chairmen are apt to say that the growth of the German contribution to world trade is due to unfair competition by way of export subsidies, and that of Japan to low wages; any difficulties of their own are blamed on State interference and high State expenditure leading to high corporate taxation; and any lack of initiative on their part to high individual taxation. In fact, the best of our industrial companies – if not whole industries – can and do compete effectively with their opposite numbers in Germany and Japan and, for that matter, in the United States. My investigation suggests that the level of corporate taxation here is much closer to that in the United States than is commonly supposed, while my own experience as an executive during a period in the United States showed me that in terms of purchasing power rather than exchange rates (except for " star " pay) the level of individual taxation is very much the same there as here. Similarly, we are often told that the British working man – " operative " is the ugly jargon word – no longer works as he did. Relatively few leading industrialists say, as has Sir Ewart Smith in relation to productivity,* that this is primarily a matter for management, he quoting most tellingly in this context Napoleon's maxim, " there are no bad privates, only bad generals."

USING TECHNICAL MANPOWER

Finally, it is often held that any backwardness in design, productive equipment or even selling skill, arises from lack of sufficient competent technical manpower by comparison with our competitors abroad. I hope to show convincingly that we are by no means as badly off in this respect as is widely believed: the real problem is to use our trained technical manpower to better advantage rather than to wait for the increased output of trained manpower to become effective or for a change of emphasis in education from the classics to technology. The problem in terms of technical manpower is similar to that stressed by Sir Henry Tizard to the Association in 1948.† He said that, from the national standpoint, it was more important to apply fully what was already known than to engage heavily in new research, important as that was for its own sake.

Altogether, I suggest that this is not a time for

* Paper entitled "Status of the Engineer in Management" read before Section G of the British Association at Oxford on September 7, 1954.

† E. A. G. Robinson, *Three Banks Review*, March, 1954, page 4.

‡ *Ibid.*, page 12.

§ *Digest of Statistics for* 1952, H.M. Stationery Office.

* E. A. G. Robinson, *Three Banks Review*, March, 1953, page 8.

† Prepared by P. R. Fisk, Assistant in Statistical Research in the Faculty of Economics at Cambridge University, and based on "World Trade in Manufactured Commodities, 1899-1950," by H. Tyszynski, *The Manchester School of Economics and Social Studies*, vol. xix, No. 3; 1952 figures from the *Board of Trade Journal*, March 29, 1954, page 629, except for India and Switzerland, estimated from other data.

* *Report of B.I.M. Annual Conference*, 1953, page 19, *et seq.*

† " The Passing World," Presidential Address to the British Association, September 8, 1948.

TABLE I.—Relative Importance of Eleven Countries in World Trade in Manufactured Goods, 1899-1952. (Percentages)

Country	1899	1913	1929	1937	1950	1952
United Kingdom—Total exports	32·5	29·9	23·6	22·4	25·0	21·3
Metal goods	35·4	26·9	19·7	18·8	26·0	20·1
United States—Total exports	11·1	12·5	20·7	19·6	29·1	25·9
Metal goods	22·7	21·6	33·5	29·0	35·3	34·5
France—Total exports	15·8	12·9	11·2	6·4	10·2	9·1
Metal goods	7·9	7·5	7·5	4·4	8·1	7·5
Germany—Total exports	22·2	26·4	21·0	22·4	7·1	11·8
Metal goods	20·5	31·0	22·3	24·4	8·4	13·1
Belgium—Total exports	5·6	4·9	5·5	5·9	5·8	7·1
Metal goods	6·7	5·5	6·0	6·6	5·5	7·5
Italy—Total exports	3·8	3·6	3·7	3·6	3·8	3·1
Metal goods	0·6	1·3	1·2	2·1	2·4	2·2
Sweden—Total exports	1·0	1·2	1·7	2·5	2·7	2·9
Metal goods	1·8	1·8	2·2	3·3	3·1	3·0
Switzerland—Total exports	3·9	3·1	2·8	2·9	4·0	3·6
Metal goods	3·5	2·8	2·9	3·0	4·4	3·9
Canada—Total exports	0·3	0·7	3·5	5·0	6·1	6·8
Metal goods	0·3	0·7	3·4	5·0	4·8	5·6
India—Total exports	2·3	2·4	2·4	2·1	2·9	4·6
Metal goods	—	0·1	0·5	0·5	—	—
Japan—Total exports	1·5	2·4	3·9	7·2	3·3	3·8
Metal goods	0·6	0·8	0·8	2·9	2·0	2·6
Total exports	100·0	100·0	100·0	100·0	100·0	100·0
Metal goods	100·0	100·0	100·0	100·0	100·0	100 0

excuses but to examine cold-bloodedly what is the present position of the engineer in the direction of the industry and to do something about it: to say, as many do, that the engineering industry has achieved much in war and peace is not to say that more is impossible. The Government of the day can do no more than set the stage; the audience is the market of the world; the management of each company must do the acting. For what part is each management fitted? Where are the engineers among them?

MANAGEMENT OF THE ENGINEERING INDUSTRY

The power to decide the policy of a company lies with its board of directors, as does the responsibility for its execution. Each year, led voluntarily by enlightened managements and with increasing detail enforced on the laggards by each revised version of Company Law, directors must report to shareholders on their stewardship. Although large shareholdings in individual companies can still be found, the trend both in this country and the United States is for the size of individual shareholdings to decline and the number of shareholders in any one company to increase.

These tendencies make effective protest difficult, and unfortunately rarely do more than a handful of shareholders meet the directors at the annual breast-beatings or beanfeasts. The small shareholder who disagrees with either the policy or performance of the directors he theoretically appoints has to take infinite trouble and incur expense to mobilise anything like an effective opposition, and apathy among fellow-shareholders inevitably works on the side of the sitting board. Then the disgruntled shareholder is nearly always in a minority and his only real recourse (in the case of a public company) is to part with his shareholding through the Stock Exchange – by no means satisfactory to him if the price he gets is less than he paid. Thus for my purpose here ownership is far less important than management, and our attention should be concentrated on the boards of companies.

Boards of public companies may consist either predominantly of full-time executives of the companies they help to direct, or effective power in all but main policy may lie with the managing director (sometimes aided by deputies below and a chairman above), the rest contributing no more than once a month or so. In either event the full board is responsible under the law of the land. The board, as well as raising capital, spending it on assets and recommending dividends must, through its chief officers, control the individual executives responsible for buying and selling, designing and making, and select them and their assistants for these key positions. Thus, whether we can for the future "combine originality in science with enterprise and speed in its application"* depends on the calibre, training and experience of the boards of British engineering companies, a self-selecting aristocracy some 4,000 strong. Since to become a corporate member of any of the three major Institutions (of Civil, Mechanical and Electrical Engineers) as I shall show, demands on the one hand a high standard of theoretical knowledge over a wide field comparable if not equal to that obtained in a university degree, and on the other, practical training and substantial experience in engineering management, a high proportion of engineers might be expected as directors of engineering companies.

To show the position in 1952 I have prepared Table II for the public companies in the British engineering industry. I estimate that together they account for something like four-fifths of our engineering exports (47·5 per cent. of the total) and probably not much different in terms of total output. Their combined issued capital is about 25 per cent. of all public companies in the commercial and industrial fields and 18 per cent. of all forms of public companies, including such services as waterworks and so forth, but excluding nationalised industries and municipal services.

* Sir Henry Tizard, "The Passing World."

A number of qualifications need making in connection with Table II:

(*a*) No subsidiary companies are included, so that (for example) where an engineering company is subsidiary of a company not in the engineering industry, no entry has been made; this affects, among others, the optical goods industry where one of the large concerns is a subsidiary of a film producing and distributing organisation.

(*b*) Many companies produce goods in a number of different fields and I have myself chosen the group into which each company has been placed. This arbitrary method is inevitably subjective although based generally on the standard reference works; but a different selection might alter the order in which industries appear in the table, which is in descending order of technical strength of the combined directorates.

(*c*) There is some double counting of directors both in that capacity and where their professions are known, but I do not consider that for the purpose here it is statistically significant.

(*d*) The information in the table is necessarily based on works of reference covering 1952, but which do not have the same date of going to press, but here again I do not think the inaccuracies are statistically significant.

(*e*) The heading "other qualifications" than membership of the three major institutions includes those bodies listed in the Appendix; but this category is not completely accurate and under-estimates those who are members of other technical bodies and who have university degrees in science or engineering by about 10 per cent.

(*f*) Only public companies with shares quoted on the London or Provincial Stock Exchanges are included.

(*g*) I have listed companies as having a technically qualified chief executive when any one of several chief officers is qualified, and to this extent this group is larger than in truth it deserves.

DIRECTORS WITHOUT TECHNICAL QUALIFICATIONS

Despite these qualifications, I believe the figures reveal in a new way the small extent to which chartered engineers take part in the direction of the engineering industry of this country, and a number of significant points emerge.

First in importance is the remarkable fact that more than two-thirds of the directorial oligarchy were (in 1952) without technical qualifications, while the industries in the top part of the table are what I believe to be generally agreed as those competing most effectively in world markets. The big half-way cases are shipbuilding and vehicles, the sectors where post-war shortages have been most marked. Among shipowners now price and delivery are the key points; in vehicles, the suitability of design for overseas use and good service: these are precisely the point where technical skill can make a decisive contribution to management and it is ominous that both these big groups only reach the middle of the table.

Secondly, as the last two columns show, it is predominantly the smaller companies in each industry which are without technical men among their directors, the most important exception being shipbuilding. This is particularly true of the heavy electrical and vehicle industries, and counting the larger firms only in these would raise the ranking of these industries in the table. But the fact remains starkly that in the board rooms of well over a third of the public companies in the engineering industry – about a quarter of the total capital – no qualified technical voice is ever heard.

ACCOUNTANTS' PLACE

Thirdly, although 9·5 per cent. of the directors of engineering companies in 1952 were accountants, there is not yet statistically one for each company although there is statistically one technically qualified director. Engineers have been saying among themselves for some time past that the top positions in their industry are given increasingly to accountants; but despite a number of notorious cases, the table shows that 28·5 per cent. of all the companies have a chartered engineer in at least one of the top jobs – chairman, managing director, and so forth – although I should add that of the 460 directors (in these 207 companies) holding such offices as chairman, deputy chairman, managing director, assistant managing director, etc., 210 have no technical qualification. As to the position of accountants, enlightened engineers recognise that the art of accountancy (and the accountant, too) as an aid to effective management has advanced markedly in the last 25 years. The company's accountant in the practice of his trade necessarily has to take part in all aspects of its affairs, while at least some engineers are unwilling to equip themselves to do likewise by understanding arts other than their own. Moreover, accountancy is common to all forms of enterprise, while the contribution of the engineer, even to the engineering industry, is not yet recognised at its true potential; so that an accountant can get wider experience than the engineer without incurring the odium of changing jobs too often. Among the larger American corporations a similar trend to promote men who have spent their working lives in them is beginning; but generally there the prejudice – and it is prejudice – against the man who has had several employers is less than here, since varied experience is recognised as valuable.

A comparison with the nationalised industries is perhaps worthwhile making: their total

TABLE II.—MANAGEMENT OF THE BRITISH ENGINEERING INDUSTRY IN 1952 —

	Industry	Per cent. of Technically Qualified Directors	Number of Companies	Total Capital, £'000	Total Directors	Chartered Engineers	With Other Technical Qualifications or Univ. Degrees in Science or Engineering	Accountants
a	Aircraft and components	42·5	20	13,839	128	22	32	15
b	Railway, marine and mining equipment	32·5	63	35,548	372	94	27	28
c	Heavy electrical equipment	28·0	72	116,939	447	111	13	35
d	Internal combustion engines (not vehicles)	27·5	13	18,918	80	18	4	10
e	Structural and civil engineering	22·5	69	29,954	404	58	32	48
f	Heating and ventilating equipment	22·0	36	20,157	214	29	18	17
g	Shipbuilding and repairing	21·5	22	78,275	150	22	10	8
h	Machine tools and other manufacturing equipment	19·0	86	42,194	484	69	22	50
i	Road vehicles, cycles, components and accessories	18·5	121	138,325	662	101	20	65
j	Light electrical engineering, including radio, etc.	18·5	40	30,220	218	35	5	22
k	Instruments	16·5	22	12,931	110	15	3	8
l	Various other branches	15·5	56	50,538	321	38	12	31
m	Castings, forgings, stampings and pressings	14·5	63	15,632	319	36	10	36
n	Agricultural, contractors and earth moving equipment	14·0	24	11,048	135	15	4	6
o	Office equipment	9·5	18	12,659	104	7	3	11
	Total	21·5	725	623,206	4,148	670	215	390

capital liabilities are some four times that of the engineering industry examined here. The total number of directors was 75 in 1952, including the two air-line corporations; the three in the fuel and power group; transport; iron and steel; and Cable and Wireless.

Table III shows that from the technological point of view the boards of the nationalised industries and services are stronger than those of the engineering industry as a whole and indeed stronger than any section of it save aircraft. But 75 directors are managing eight industries together four times the size of the engineering industry divided into 725 units with over 4,000 directors. So in these vast undertakings the level of technical attainments lower down the scale is more important than in the relatively much smaller concerns in the engineering industry.

TABLE III.—*Comparison of Main Nationalised Industries with the Engineering Industry in* 1952

—	Technically Qualified Directors	Chartered Engineers	Accountants
	Per cent.	Per cent.	Per cent.
Nationalised Boards	36·0	26·5	5·5
Engineering industry	21·5	16·0	9·5

STRENGTH OF THE ENGINEERING PROFESSION

Qualified Engineers and Working Population.—Although chartered engineers fare so poorly at the apex of the industry they have created and maintained, they do fill many important subsidiary positions in their own and other industries and services. This aspect is, however, outside my scope here, as it seems to me that the direction of the engineering industry (and so its future) is of most critical importance to our economic survival. But since the argument might be made that because engineers fill such positions there are not enough also for the apex, a comparison of the numbers available with the jobs to be done is worth making. The simplest way to illustrate this has been chosen in Table IV. The table shows a striking change during the Twentieth Century, the ratio of chartered engineers to the working population having increased by a factor of four to the proportion now of one chartered engineer to 527 of the working population.* Thus it seems fair to say that if the will to use engineers to the full were more prevalent, there are sufficient to go round both to run the services to the community, the lower levels of management and to increase their strength on the boards of companies in the engineering industry, unless the expansion in quantity has been achieved at the expense of quality.

* Accountants are in about the same ratio. *The Times*, June 8, 1954, page 9.

TABLE IV.—Comparison of Working Population and Chartered Engineers in the United Kingdom

—	1952	1942	1932	1922	1912	1902
Institution of Mechanical Engineers*—Corporate Membership	18,884	9,179	6,753	5,672	4,132	2,914
Institution of Electrical Engineers—Corporate Membership	14,744	9,007	6,278	5,456	3,783	1,507
Institution of Civil Engineers—Corporate Membership	9,236	7,457	6,232	5,480†	4,910†	4,110†
Total	42,864	25,643	19,263	16,608	12,825	8,531
Working population (millions)‡ ..	22·61	22·30	21·22	19·52	18·45	16·52
Ratio of engineers to working population ..	1 : 527	1 : 870	1 : 1,102	1 : 1,175	1 : 1,439	1 : 1,936

* Close estimate.
† Assessed at 66·6 per cent. of total membership. U.K. percentage increased from 69 per cent. in 1925 to 75 per cent. in 1952.
‡ Estimated from census figures from 1901, 1911, etc., except for 1942 which is based on 1938 estimate.

Qualifications for Membership of the Major Technical Institutions.—While the three major institutions have expanded, as I have shown, new institutions with separate memberships were being established, and have indeed become accepted in the technical fraternity. If these too could be tabulated in the same way, I have no doubt that the ratio would show an even more striking change. But as I want to stick to the general rather than be drawn into the relative importance of different institutions, I have considered only the membership qualifications for the major institutions.

In fact, this great change in the numerical strength of the engineering profession in the United Kingdom has been accompanied by great changes in the educational standards needed to qualify as a corporate member of these major professional institutions. Practical training and experience in the engineering industry, holding a position of responsibility in it, and the sponsorship of candidates by existing members were – and still are – cardinal principles governing admission to membership. Candidates can still be admitted on these grounds if in addition a thesis of the candidates' choice has been presented and accepted. But since 1913 (in the case of the Institution of Mechanical Engineers) a new hurdle – an examination conducted by the Institution – has been made, unless a candidate is regarded as exempt in whole or part by having reached similar standards in other examinations of at least equal status.

INSTITUTION EXAMINATIONS

Hence the significance of a summary of how the syllabus has been changed by the Council of the Institution to keep up with both technological changes and the increased knowledge of human relationships required of aspirants to "top management" – a horrid phrase now so fashionable. These changes fall into two classes: first, the extended scope of the old subjects; and secondly, new subjects, probably more important for my purpose.

Throughout the period, subjects for the Institution examination have been grouped into compulsory and a selection of optional ones – groups designed to bring out respectively general and scientific knowledge on the one hand and more specialised technical knowledge on the other. In 1913-1914 general knowledge was exemplified in an essay dealing (at the candidates' option) with a set subject in literature, science, technology, or economics and workshop organisation – an odd combination. The scientific group – four times the importance of general knowledge, judged by the length of examination time – demanded of the candidate that he should know both applied mathematics and physics and chemistry. The technical group – equal in importance to scientific knowledge – allowed the candidate to select two from these subjects: properties and strength of materials, steam and steam engines, internal-combustion engines, hydraulics and hydraulic machinery, electrotechnics and the design of electrical machinery, theory of machines and machine design, and metallurgy.

No changes had been made by 1919 but by 1924 the transition to the present-day had begun. General knowledge disappeared and a modern language became compulsory; mathematics, physics and chemistry remained, as before, compulsory. Theory of machines and machine design, and properties and strength of materials also became compulsory, and the choice of one specialised subject correspondingly reduced to steam and the steam engine, the internal-combustion engine, hydraulics and hydraulic machinery, electrotechnics or metallurgy. A completely new section – the economics of engineering – was added, divided into three parts: First, a short essay on a subject of historical or general interest in mechanical engineering or related to the mechanical engineering resources of the Empire, and set with the object of testing a candidate's power of expression. Secondly, general economics including private and national wealth, laws of supply and demand; foreign exchanges, cycles in trade and credit; trade unions and employers' associations, joint stock companies; methods of marketing and advertisement, relation of natural resources to specific manufactures, and the effects of the principal inventions in mechanical engineering. Thirdly, workshop organisation and management, including the duties of different levels of management, works lay-out, payment by results, standardisation, estimating, direct charges and "on costs," and the relationship between science and engineering research. The introduction of this new section as compulsory clearly recognised the importance of wide knowledge in the technical training of engineers, and one-seventh of the examination time was allowed for it.

By 1936 a foreign language became an alternative to an English essay, coupled with the fundamentals of industrial administration (taking in the guts of what had been called the economics of engineering), whilst workshop organisation and systematic management (including recruitment and training of staff, purchasing and keeping of stores, sales organisation and tendering) had been made a three-hour subject on its own, then under just one-seventh of the total examination time. To the list of optional subjects of specialised knowledge, aeronautics had been added although radio still remained outside the electrotechnical ambit. By 1939, workshop technology had been made a seventh optional subject includ-

— SHOWING THE SMALL PART PLAYED BY ENGINEERS

Per cent. of Chartered Engineers	Per cent. of Accountants	Per cent. of unspecified Professions	Companies with a Chartered Engineer as Chief Executive		Companies with Chief Executive having other Technical Qualifications		Companies with Chartered Engineers on Boards (not as Chairman, etc.)		Companies having Directors with other Technical Qualifications (not as Chairman, etc.)		Companies having no Technically Qualified Director		Per cent. of Companies having Wholly Non-technical Boards		
			No.	Capital £'000	No.	Capital £'000	No.	Capital £'000	No.	Capital £'000	No.	Capital £'000	By No.	By Capital	
17·0	12·0	45·5	3	4,483	3	4,324	7	1,842	2	351	5	2,839	25·0	20·5	*a*
25·5	7·5	60·0	31	24,174	10	3,573	5	1,548	1	100	16	6,153	25·0	17·5	*b*
25 0	8·0	64·0	34	69,387	18	34,417	1	246	2	486	17	12,403	23·5	11·0	*c*
22·5	12·5	60·0	5	2,617	4	11,700	1	800	0	0	3	3,701	23·0	20·0	*d*
14·5	12·0	65·5	16	8,754	13	5,308	10	6,533	6	2,184	24	7,155	35·0	24·0	*e*
13·5	8·0	70·0	8	3,924	3	4,752	2	742	7	1,602	16	9,137	45·5	43·5	*f*
14·5	5·0	73·5	7	9,756	4	7,019	3	6,883	1	22,701	7	31,916	32·0	41·5	*g*
14·0	10·0	71·0	26	13,126	17	11,123	1	150	2	596	40	17,199	46·5	40·5	*h*
15·5	10·0	71·5	29	42,276	30	66,329	4	3,069	7	6,672	51	19,978	42·0	14·5	*i*
16·0	10·0	71·5	8	1,974	11	10,210	2	1,122	—	—	19	16,914	47·5	56·0	*j*
14·0	7·5	76·0	5	1,099	5	3,439	—	—	—	—	12	8,393	54·5	64·5	*k*
12·0	9·5	75·0	13	21,964	12	8,563	4	1,973	1	6,012	26	12,026	46·5	23·5	*l*
11·0	11·0	74·5	15	3,693	9	3,378	1	482	3	460	35	7,619	55·5	49·0	*m*
11·0	4·5	81·5	5	1,461	6	2,934	—	—	—	—	13	6,653	54·0	60·0	*n*
6·5	10·5	80·0	2	3,545	3	2,439	1	300	3	2,237	9	4,140	50·0	32·5	*o*
16·0	9·5	69·5	207	212,233	152	179,506	42	25,810	35	43,401	293	166,226	40·5	27·0	

ing, for example, classification of steels by properties, form of supply and relative costs; inspection and measurement; and machine-shop practice – in fact most of what has now come to be called " production engineering."

The post-war examination syllabus recognised on the one hand that the rapid growth in knowledge must lead to a proliferation in optional subjects and, on the other, to some re-titling in the syllabus covering fundamental subjects to march with the frontiers of the new 'ologies. English and engineering drawing have been added to mathematics, applied mechanics and strength of materials and industrial administration as compulsory subjects, while a foreign language has disappeared as an optional subject. Physics and chemistry have been separated and become a group with applied heat, principles of electricity and workshop technology – of which one must be taken, as must one (and a possible second) from among applied thermodynamics, mechanics of fluids, electrotechnology, metallurgy and theory of structures.

Among the thirteen specialised subjects (instead of seven pre-war), aeronautics has been split into two. Engineering as applied to air conditioning, automobiles, refrigeration, fuel and combustion, agriculture and textiles have been added, as have metrology and machine tools. Besides, the old subjects have increased scope, for example, internal-combustion engines now include gas turbines. Altogether, no wonder the total time allowed for these papers has risen to 33 hours as against 22 pre-war and 13½ in 1913!

Exemption from these formidable rigours may be had in whole or part by, for example, an engineering degree taken at any one of 32 universities in the British Empire – 17 of them in the United Kingdom, only one more than pre-war. The significant difference over exemption for my purpose here is that the examination in industrial administration (covering the very wide field I have mentioned) remains compulsory except for those who gain an honours degree. In any case, of course, before taking – or being exempted from – all or any subjects a candidate has still to satisfy the Council of the Institution of his training and experience as a mechanical engineer.

The requirements for membership of the Institution of Civil Engineers have been progressively reviewed by that Institution – on the academic side the syllabus has been extended to meet the requirements of the day by including subjects such as soil mechanics, while the emphasis on the necessity for authenticated practical training has been increased. In this respect the Institution's professional interview (wherein all applicants for election are interviewed with regard to details of the standard they have gained in their practical experience) has played and is playing a very important part.

STANDARD MAINTAINED

The outline of the knowledge and experience which the post-war mechanical engineer must have suggests to me that, so far as these qualities are the ingredients of a man's make-up to suit him for management, the man has been kept abreast of the times. In other words, if engineers made good leaders of engineering enterprises in the early years of this century, on the basis now needed for qualification, engineers can still be so in the more complex conditions of to-day. And in this conclusion I am fortified by the fact that as the range of subjects – and each subject in itself – became greater, the standard of qualifying marks has remained the same. The gain in width has not been made at the expense of depth: a qualified mechanical engineer may possibly know about the design and use of agricultural buildings, but he must still know, for example, about the solution of plane triangles as of yore, and since 1924, about industrial administration, economics and the organisation of society.

The emphasis in the examination has properly remained on technology as against administration in the proportion of about nine to two. As a director (except for one filling the post of, for example, chief engineer) a man will need predominantly administrative rather than technical ability: this must come of a man's nature and experience. No examination can identify with precision these attributes; but a trained mind is also needed, so the chartered engineer should have a flying start.

Comparison between United Kingdom, Switzerland, Sweden and United States.—Great as has been the change in the United Kingdom in the ratio of chartered engineers to working population in the last 50 years, the improvement has been held not to have been great enough. One line of argument to support this view has been that the higher figure of national income per head of population in Switzerland and Sweden (by comparison with ours) must be due to a higher proportion of qualified men, since these countries, in contrast to the United States, are no better off in natural resources than we are. National income figures are not of course an exact index to standard of living, but are sufficiently significant to justify an attempt to compare the figures in Table IV with the corresponding figures for these other countries given in Table V.

TABLE V.—*Comparative Ratios of Chartered Engineers to Population in Several Countries* (1952)

—	United Kingdom	Switzerland	Sweden	United States
National income per head (£)	271	345	385	664
Ratio of resident chartered engineers to working population	1:527	1:803	1:436	1:548
Ratio of resident chartered engineers to population in manufacturing industries	1:197	1:312	1:138	1:143
Working population (millions)	22·61	2·18	3·16	60·65
Population in manufacturing industries (millions)	8·46	0·79	1·01	16·21
Resident chartered engineers	42,864	2,700	7,300	111,400

The figures for working population and in manufacturing industries are estimated from those for earlier years, and hence the ratios cannot be taken as exact; and the ratios cannot distinguish between the relative densities of qualified men in the various sectors of each economy. Nevertheless, the spread in the ratios on either side of those for the United Kingdom is so big that errors in estimating could not cause it. Sweden and Switzerland, both well above us in national income, are respectively far better and far worse off in qualified men: so I do not think the difference in national incomes is due so much to numbers or ratios of qualified men as to their status and the use made of them, since I for one could not accept that British engineers are less competent than their colleagues elsewhere. Indeed, I believe the matter of status is the root of our problem: the profession of engineering here lacks the prestige of the liberal professions. This in turn affects the prospects of those in the profession and influences the quality of the new entrants to it; in the United States (for example) the engineer is at least the peer of any other professional man, and the profession as a whole is well regarded by the public and as a good ladder in the material scale.

CHANGE IN STATUS IN THE TWENTIETH CENTURY

As I have already shown that the position of the United Kingdom in world trade in engineering products has changed for the worse, it seemed relevant to inquire whether this change had been accompanied by any change in the Twentieth Century in the position of the engineer as a leader of the engineering industry. For this purpose I have analysed the number and character of directorships held by members of the Council of the Institution of Mechanical Engineers over the last 50 years in ten-year steps. Out of a number of possible lines of inquiry this was selected for the simple reason that members of the Institution are elected to its Council on the general consensus of opinion of all their fellow-members that they are in all ways the best in the profession, while directorships would show the extent to which these distinguishing qualities were recognised throughout the period by industrialists at large. The disquieting result is shown in Table VI. This table clearly shows how markedly the number of directorships held by members of the Council of the Institution has declined in the last 50 years, as has the number of members of Council who hold position among the chief officers of these companies. To dispose of the possible argument that this fall may be due in part to the aggregation of smaller into larger corporate units, so that directors can have no time for the affairs of the profession, I have examined whether companies now represented on the Council are larger or smaller than they used to be, with the result shown in Table VII. The 1952 figure is heavily weighted by one

TABLE VI.—MEMBERS OF COUNCIL OF INSTITUTION OF MECHANICAL ENGINEERS HOLDING DIRECTORSHIPS

—	1952	1942	1932	1922	1912	1902	1892	1882
Members of Council	44	40	41	39	35	37	33	31
Directorships held	17(*a*) (*c*)	9	19(*a*) (*b*)	40(*a*)	38(*a*) (*b*)	52(*a*)	33(*a*)	35
Including Chairmanships, Managing Directorships	7	3	8(*a*)	17(*a*)	16(*b*)	20(*b*)	8	9
Number of Directors	13	9	12	20	16	25	17	16
Percentage of Council who were Directors	29·5	22·5	29	52	45·5	67·5	51·5	51·5
Issued capital (including debentures etc.) of all companies with Members of Council as directors in all capacities—£'000	£154,722(*b*) (*c*)	£7,055	£13,136(*b*)	£38,390(*b*)	£122,409(*c*)	£145,615(*c*)	£160,554(*c*)	—
Number of Chairmen, Deputy Chairmen, Managing Directors, etc.	6	3	8(*a*)	10(*c*)	10(*b*)	14(*b*)	7	7
Percentage holding these offices	13·6	7·5	19·5	25·5	28·5	38	21·5	22·5
Issued capital of these companies—£'000	£23,724	£2,101	£4,370(*a*)	£6,100	£23,850	£101,400(*d*)	£9,541	—
Number of Directors other than Chairmen, etc.	7	6	4	10	6	11	10	9
Issued capital of these companies—£'000	£131,098(*b*)	£4,954	£8,766	£32,296	£83,559(*c*)	£42,215	£151,013(*c*)	—

NOTES.—

1952.—(*a*) includes one Bank Directorship, capital of which is excluded; (*b*) including I.C.I. at £115,000,000; (*c*) excludes all subsidiaries and private companies except one, capital of which is known and included.

1932.—(*a*) including three Chairmen or Managing Directors of substantial private companies, capital of only one known and included; (*b*) including one of Southern Railway, capital of which at £196,472,000 is excluded.

1922.—(*a*) including four Chairmen or similar of private companies of substantial size, capital of one of which is known and included; (*b*) two companies twice represented on Council, capital counted only once in each case.

1912.—(*a*) including one of a Canadian Railway and one of a U.S. Shipping Company, two of Insurance Companies, one of Bank, capital all excluded; (*b*) including three Chairmen or similar of private companies of substantial size, but only one of which capital known and included; (*c*) including four of U.K. Railways, all capital included, one of £50,000,000.

1902.—(*a*) including one Insurance Company Director, one Insurance Company Vice-Chairman, one Bank Chairman, all capital excluded; (*b*) including one Chairman of substantial private company, capital unknown; (*c*) one company represented three times, one twice on Council, capital counted once only in each case; (*d*) including one U.K. Railway (Deputy Chairman) with a capital of £73,891,000.

1892.—(*a*) including one Bank Director and one Director of Girls' Public Day School, capital of both excluded; (*b*) includes one Managing Director of substantial private company, capital known and included; (*c*) including two U.K. Railway Companies of capital of £59,216,000 and £47,318,000 respectively.

1882.—Figures for Directorships less accurate than for previous entries in table.

director of Imperial Chemical Industries; without him, the figure would fall to £2·7 million—less than 1912. Taking into account the change in the value of industrial capital, half a century ago directors of larger companies than in 1952 found time to take their places on the Council. The truth therefore seems to be that British engineering companies are not directed by leading engineers to the extent they were when we led world trade in this field. This conclusion is supported by the low proportion of chartered engineers as a whole who held directorships in public companies in the engineering industry in 1952, given in Table VIII.

TABLE VII.—*Average Capitalisation of Companies with Directors serving on the Council of the Institution of Mechanical Engineers*

Year	Average Capital (million £)
1952	9·7
1942	0·67
1932	0·82
1922	1·1
1912	3·5
1902	3·2
1892	5·2

TABLE VIII.—*Comparison of Directorships and Membership of the Three Major Technical Institutions in* 1952

—	U.K. Resident Membership	Directors	Per Cent.
Civil engineers	9,236	124	1·35
Mechanical engineers	18,884	413	2·20
Electrical engineers	14,744	124	0·85

Pay and Status of the Engineer.—The salaries of engineers in this country have not been analysed closely as was done in the United States in 1946* but estimates have been made† which suggests that a freshly-qualified member of one of the three major institutions might expect to get about £600 a year and to reach £1,000 at the age of 35 years, if lucky; while a fair proportion might at the end of their careers reach £2,000 a year, and only a very few could expect to end with £5,000 a year or more. Those that reach the maximum figure would almost certainly be directors, as Table IX shows (based on only 639 out of the 725 companies in Table II and 3,629 out of the 4,148 directors), bearing in mind that these figures cannot distinguish between part and full-time directors.

TABLE IX.—*Average Total Emoluments of Directors in the Engineering Industry in* 1952

—	Average Emoluments per Director	Average Capital	Percentage of Chartered Engineers
	£	£'000	
Shipbuilding	5,920	3,500	14·5
Internal combustion engines	5,620	1,950	22·5
Aircraft and components	5,200	690	17·0
Vehicles and components	5,150	1,160	14·5
Instruments	4,930	580	14·0
Various	4,710	905	12·0
Machine tools and manufacturing equipment	4,340	490	14·0
Structural and civil engineering	4,170	430	14·5
Light electrical engineering	4,100	770	16·0
Heavy electrical engineering	4,050	1,640	25·0
Railway, marine and mining equipment	4,010	590	25·5
Heating and ventilating equipment	3,670	570	13·5
Office equipment	3,370	700	6·5
Agricultural, contractors and earth-moving equipment	3,350	455	11·0
Castings, forgings, pressing	3,250	250	11·0

All these tables support the view that the professional engineer in this country has suffered something of an eclipse in the last 50 years although there are now slight signs that the shadow is passing from him. A straight correlation between this eclipse and the decline in the share of world trade in manufactures achieved by the United Kingdom would be too much to suggest; to deny that the eclipse may well be a contributory cause would be equally foolish. The establishment of manufacturing industry elsewhere was inevitable and may have overtaken our early lead, while domestic production of standard articles keeps out our exports. But if the decline can be attributed in any way to lack of enterprise, skill, experience or aggressiveness among present-day directors by comparison with their forebears of 50 years ago, then we now need more of the right kind of engineers on the boards of our engineering companies.

Comparison with the United States, Sweden and Switzerland.—I had hoped to be able to compare usefully the composition of the Councils of technical institutions in this country and in the United States, Sweden and Switzerland; but despite the fact that much information has been made available to me, the disparity in the practice in membership on the one hand, and in the methods in the management of industrial undertakings on the other, has convinced me that no useful comparison can be made. So far as this country goes, if the Councils of the Institutions of Civil and Electrical Engineers are brought to a basis comparable with that of the Institution of Mechanical Engineers, three of the former and three of the latter held directorships in 1952.

SOME QUESTIONS FOR THE FUTURE

Not accident but an attitude of mind among industrialists has led to countries passing us in the industrial race. The most successful to-day is the United States, aided by great natural resources and a determination in each individual to get what he wants in the material sense and a readiness to meet any need. There, in contrast to this country, practically anything is believed possible and most things worth trying. We need new products, new and better ways of doing things, if we are to recapture our place in world trade. A cautious climate curbs imagination and drive in all men, and frustrates the urge of the technical man to find out. Must our negative attitude endure ?

Technical qualifications are clearly of importance in the leadership of each company in the engineering industry. These leaders require imagination. They have to be conscious of new possibilities. They have to have the judgment and sense of timing needed to choose the most likely and the most suitable directions for new work. They must have an intense interest in the technicalities of their particular branch of the engineering industry so that they can force the pace of the staff below them. They have to have administrative ability to organise both the technical and production work and selling and buying activities. They must possess the ability to define the objectives of their company and to make them equally clear to their staff. They have to give a sense of urgency and encourage initiative while holding a sensible balance between sound but plodding progress and the taking of technical risks, without which any engineering enterprise becomes sterile. They have to fight a constant battle against mediocrity, and to get first-class work out of second-class people. In theory directors recommend for election by the shareholders their new colleagues; in practice the process is so one-sided as to amount to parthenogenesis. Are the qualities I have described sought for in making new appointments to boards ?

But technical ability alone is not enough. A board of directors, particularly where the majority are also full-time executives and heads of departments, must be able to work together, and it is perhaps one of the most important functions of chairmen and managing directors to select their colleagues with this point in mind. Ability to work together gives even the moderate administrator the setting to do his job well. Administration boils down to deciding what should be done by when and who should do it, providing the tools and the setting for the work, and seeing that progress is made to plan. In an engineering enterprise these are largely engineering issues. Do boards recognise this?

If engineers are to take the place due to them in board rooms they too must equip themselves for the part, not only by keeping ahead in their own field but by conscious effort to understand the nature of the world and the need for change in the engineering industry if that of the United Kingdom is to make its potential and needed contribution to our prosperity and standard of living. Engineers must therefore turn their attention to all the tools of management and be expected to understand what art there is in selling and what contribution costing can make and what the newer sciences, grouped under the term " social engineering," can do for better selection, training and performance of the whole team. Can this be claimed for our engineers?

COMPOSITION OF BOARDS

Any change in the boards of our engineering companies is likely to be gradual. The average tenure of a directorship in this country is between 14 and 17 years, while membership of a technical institution may endure for 30 years, the former beginning at 45 to 50, and the latter at around 29 years. In the nature of things, somewhere between 250 and 350 new directors are promoted to such offices each year and it is in this field that changes might well begin. Inevitably, the chief officers of companies seeking new directors look first among their own employees and secondly to those they know in similar concerns or to distinguished men in other walks of life. For example, the board of one large company includes three generals and two peers (distinguished respectively as a diplomat and a governor general) and a knight; the only technically qualified man is a commoner. In the United States the practice seems to be, in all but the larger companies, to select from a wider field. In this country advertisement is rarely used, neither is the Technical and Scientific Register of the Ministry of Labour, as the figures in Table X for vacancies here and overseas show.

Some 75,000 people are recorded in the Register, of whom about 5,000 are at any one time seeking new outlets for their energies and abilities, not necessarily of course because they are unemployed: they are merely up against the barrier to circulation and wider experience in this country. Here, therefore, seems a ready-made reservoir if boards of directors were prepared to seek new colleagues in new ways. Will new ways be used?

The prospect for the chartered engineer to reach the most influential or best paid positions could not now be called bright when they are outnumbered for these posts by nearly five to one. The truth is that here the technical and non-technical men often seem to one another to live on different planes and breathe different air, partly at least because so many chartered engineers have missed the free interchange of thought found in residential educational establishments such as universities. Each tends to think of the other in terms of equal acerbity, illustrated by what Charles Francis Adams wrote of his business acquaintances in 1912: " Indeed, as I approach the end, I am more than a little puzzled to account for the instances I have seen of business success – money-getting. It comes from a rather low instinct. Certainly, so far as my observation goes, it is rarely met with in combination with the finer or more interesting traits of character. I have known, and known tolerably well, a good many ' suc-

TABLE X.—VACANCIES NOTIFIED AND FILLED THROUGH MINISTRY OF LABOUR—SALARY £1,500 OR MORE—UNITED KINGDOM AND OVERSEAS

Year	Civil Engineering		Electrical Engineering		Engineering other than Civil and Electrical		Total	
	Notified	Filled	Notified	Filled	Notified	Filled	Notified	Filled
1952	106	8	45	11	111	4	262	23
1953	97	9	50	2	90	15	237	26

* " Engineering Profession in Transition ": Engineers Joint Council, New York, 1947.

† *Professional Men*, by Roy Lewis and Angus Maude, London, 1952.

cessful' – 'big' financially – men famous during the last half-century; and a less interesting crowd I do not care to encounter. Not one that I have ever known would I care to meet again, either in this world or the next; nor is one of them associated in my mind with the idea of humor, thought or refinement. A set of mere money-getters and traders, they were essentially unattractive and uninteresting."* But in the last 40 years the position in the United States has changed: engineers have largely replaced financiers and bankers in leading positions in many other industries as well as engineering, while the social and intellectual barriers between technical and non-technical men have been broken down. The effect on American industry has undoubtedly been good, and although an indentical metamorphosis is not needed here, the contrast of British engineers being outnumbered as directors by five to one does need redress. Should not the eclipse of the engineer in management be ended?

Acknowledgments.—The only real difficulty in preparing an analysis of the kind I have ventured to present is to get time to do it and needed help and encouragement from others. While naturally I am myself responsible for this paper I have had valuable advice in its preparation from Sir Henry Tizard, Sir Ewart Smith, Sir Harold Roxbee Cox, Professor E. A. G. Robinson, Professor W. R. Hawthorne and Mr. H. Hodgson. In the preparation of the figures I have been aided by the accountancy staff of Spicers, Limited, Mr. P. R. Fisk, members of the staffs of the Institutions of Civil, Electrical and Mechanical Engineers (particularly the last), the Central Statistical Office, the Ministry of Labour, Mr. D. W. Mansell of Long Island, New York, Svenska Tecknologforeningen, and Schweizerischer Ingenieur-und Architekten-Verein; and by Mrs. O. M. Easson in the preparation of the manuscript.

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APPENDIX

Technical Institutions, Other than the Three Major Institutions considered in Table II.
Royal Aeronautical Society
Institution of Production Engineers
Institution of Chemical Engineers
Institution of Structural Engineers
Institution of Heating and Ventilating Engineers
Institute of Welding
Institution of Naval Architects
Institution of Gas Engineers
Institute of Fuel
Institute of Marine Engineers
Institution of Locomotive Engineers

Accountancy Institutions considered in Table II.
Institute of Chartered Accountants in England and Wales
Society of Incorporated Accountants and Auditors
Institute of Chartered Accountants of Scotland
Institute of Cost and Works Accountants

* *Charles Francis Adams*, 1835-1915. Boston, 1916.

Correspondence on this British Association paper will be considered for publication in "Engineering."

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MATERIALS HANDLING

With the aim of assisting smaller manufacturers to reduce their handling costs, arrangements have been made by the materials handling sub-committee of the Institution of Production Engineers to hold a one-day conference at the works of John Wright and Company (Radiation) Limited, Birmingham, on Saturday, October 23. There will be a morning session devoted to a tour of the works and an afternoon session for lectures and discussions. Apply to the Institution, 10 Chesterfield-street, London, W.1.

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Metallic Resistance Materials for Electrical Purposes. (3*s.*, post free.)

A third revision of specification B.S. 115 has been issued. It covers metallic resistance materials in the form of wire, strip, tape and sheet for electrical purposes and was first published in September, 1921. Revised editions were issued in September, 1924, and January, 1938. In the present 1954 edition, the resistance materials are divided into three classes, compared with five in the 1938 edition. These comprise: Class A. – Applications where a low-temperature coefficient of resistance is of primary importance. Class B. – Applications where the temperature coefficient of resistance is important but may be larger than that permitted for Class A. Class C. – Applications where the working temperature is above 250 deg. C. or where the temperature coefficient of resistance may be larger than that permitted for Class B. Class C is sub-divided into Classes C1 to C6, corresponding to steps in maximum working temperature from 350 deg. C. to 1,300 deg. C. The electrical requirements dealing with resistivity and resistance and appropriate tolerances are unchanged, as are the tolerances on dimensions of metallic resistance materials in their various forms. All references to resistance castings have been omitted and it is stated that it has not been found practicable to specify satisfactory tests to prove the maximum working temperature of resistance materials, owing to the great variability in test conditions.

Coal Cutter Picks and Pick Boxes. (2*s.*, post free.)

Two of the objects of a new specification, B.S. 2477, covering coal cutter picks and pick boxes, are to provide interchangeability between the picks made by different firms, and to reduce, as far as is consistent with efficiency, the number of types and sizes in order to simplify ordering and manufacture. The dimensions necessary to ensure interchangeability and the requirements for the minimum cutting gauge of the picks are specified, and the standard also provides for the effective fastening of the pick shank in the pick box. In order to distinguish between the different types of picks used, the one having a hard-metal (tungsten carbide) tip, brazed either on the surface of the body or in a slot, is designated: "pick, brazed-on tip type." All other types are designated: "picks, other than brazed-on tip type." No specification for materials has been included in the present edition.

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BOOKS RECEIVED

Year Book of the Heating and Ventilating Industry, 1954. *Technitrade Journals, Limited*, 8 *Southampton-row, London, W.C.*1. (7*s.* 6*d.*)

Strength of Materials. By ARTHUR MORLEY. Eleventh edition. *Longmans, Green and Company, Limited*, 6 *and* 7 *Clifford-street, London, W.*1. (21*s.*)

Significance of Properties of Petroleum Products. Edited by GEORGE SELL. *The Institute of Petroleum*, 26 *Portland-place, London, W.*1. (7*s.* 6*d.*)

Telecommunications. By A. T. STARR. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (35*s.*)

Mechanics of Materials. By PHILIP GUSTAVE LAURSON and WILLIAM JUNKIN COX. Third edition. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (46*s.*)

Copper: The Science and Technology of the Metal, its Alloys and Compounds. Prepared under the Editorial Supervision of ALLISON BUTTS. American Chemical Society Monograph No. 122. *Reinhold Publishing Corporation, Book Division*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.*; and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (160*s.*)

A Study of Concreting Methods on Housing Sites. By K. G. H. FRYER and J. F. EDEN. National Building Studies Special Report No. 23. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*).

Radio Laboratory Handbook. By M. G. SCROGGIE. Sixth edition. Published for "Wireless World" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (25*s.*)

A History of the School of Engineering, Columbia University. By JAMES KIP FINCH, Dean Emeritus of the Faculty of Engineering. *Columbia University Press, Morningside Heights, New York* 27, *N.Y., U.S.A.* (2·75 dols.); and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (22*s.*)

Elementary Fluid Mechanics. By JOHN K. VENNARD. Third edition. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (44*s.*)

A Selection of Graphs for Use in Calculations of Compressible Airflow. Prepared on behalf of the Aeronautical Research Council by the Compressible Flow Tables Panel. *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (84*s.*)

Manual of British Water Supply Practice. Compiled by the Institution of Water Engineers. Edited by AUBREY THOMAS HOBBS. Second edition. Published for the Institution of Water Engineers by *W. Heffer and Sons, Limited, Cambridge*. (55*s.*)

The Wheels of Progress: A Review of Productivity in the Diesel Locomotive Industry. *The British Productivity Council*, 21 *Tothill-street, London, S.W.*1. (2*s.*) (Reviewed in the issue of August 27, page 257.)

Elements of Mechanism. By Professors VENTON LEVY DOUGHTIE and WALTER H. JAMES. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (48*s.*)

Electronics. By Professors GEORGE F. CORCORAN and HENRY W. PRICE. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (56*s.*)

Zur Theorie des vollkommenen und unvollkommenen Brunnens. By Dr.-Ing. GÜNTHER NAHRGANG. *Springer-Verlag, Reichpietschufer* 20, *Berlin, W.*35. (7·50 *D.M.*)

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TRADE PUBLICATIONS

Fans and Ventilating Equipment. Three illustrated brochures have been received from Keith Blackman, Ltd., Mill Mead-road, Tottenham, London, N.17. The first of these deals with the Tornado bifurcated range of fans which are designed to handle obnoxious fumes, dust-laden air or gases at relatively high temperatures; the major advantage of this unit, which is available in sizes from 10-in. to 25-in. diameter, is that the fan casing is divided to isolate the motor from the gases. The second catalogue covers the Tornado range of high-efficiency axial fans with V-rope drives and an externally mounted motor; the sizes of this type range from 16-in. to 48-in. diameter for volumes from 1,000 to 40,000 cub. ft. per minute and pressures from 0·1 in. to 4 in. static water gauge. The third describes the makers' equipment for marine use.

Centrifugal Pumps. A copy of a new brochure giving details of a range of centrifugal pumps suitable for corrosive liquids and fluids carrying abrasive materials has been received by us. The makers of these pumps are Wilkinson Rubber Linatex, Ltd., Camberley, Surrey.

Centralised Lubrication System. A brochure has been published by Tanway, Ltd., Barnaby Dun, Doncaster, which outlines the principle and operation of their G.P. centralised lubrication system. A simple grease container is used with either a manual or power-operated pump and multiple feeder blocks re-direct the grease by way of small-bore tubing to the various moving parts on a machine.

Constructional Sets. An illustrated leaflet describing the Kandu construction equipment using a standard drilled angle-section has been received from Geo. W. King, Ltd., Stevenage, Herts. It is suitable for constructing storage racks, cranes, and conveyor systems.

Portable Saws for Steel Sections. An illustrated leaflet, describing a small powerful petrol engine with four attachments for cutting, drilling and grinding rails and other steel sections, has been received from the Howard Pneumatic Engineering Co., Ltd., Fort-road, Eastbourne, Sussex. The equipment, has been made light so that it can be carried by one man.

THE EFFICIENT GENERATION OF INDUSTRIAL STEAM*

REDUCING LOSSES IN FLUE GASES

By D. C. Gunn†

Steam, generated mainly by the combustion of coal, has always been the main source of heat and power in industry. Whether this will be so in the more distant future is problematical, but the present productive capacity of Great Britain is almost entirely dependent on the adequacy of the coal supply. The country is now threatened with a crisis; it is estimated that the demand for heat and power is increasing at a rate which exceeds the rate of increase of coal output. It would appear that by 1965 there will be a deficiency in coal production of perhaps 20 million tons per annum.[1] Three expedients, which would remedy the situation, are: an increase in coal output, the import of coal or oil, and a reduction in the demand for coal.

Perhaps the least acceptable of these expedients is to import fuel when other, more desirable, commodities could be imported instead. Likewise, to attempt to use the nation's most important (though wasting) asset, coal, at an increasing rate, even if possible, might prove suicidal – if not for this generation, then for the next. The most satisfactory solution would be to reduce the demand, not by limiting the services provided, but by making sure that fuel is burned with the greatest practicable efficiency. It is the purpose of this paper to examine what improvements are possible in coal utilisation in industrial boilers.

SCOPE OF THE PROBLEM

The Ministry of Fuel and Power Statistical Digest for 1952 shows that coal was distributed as shown in Table I. The statistics do not go

TABLE I.—*Coal Distribution in Thousand Tons*, 1952

General Industry	Collieries	Electricity Works	Railways
42,981	10,155	35,785	13,908

farther than this in analysing the industrial utilisation of coal but it would seem that the greater part of these categories of consumption is used for steam raising. Thus, some 100 million tons of coal, or about half the total distributed in this country, is burned in boilers of various kinds. No recent survey has been carried out to determine the average efficiency of raising steam, although in 1920 Brownlie[2] published figures which suggested that this was very little more than 60 per cent. There is no reason to believe that the present average efficiency of industrial steam raising exceeds this figure; indeed, it may well be less as a result of the deterioration in the quality of fuel and labour which has taken place over the years. This would mean that 40 per cent. of the 53 million tons of coal supplied to general industry and the collieries is wasted, quite apart from the inefficient utilisation of steam which is outside the scope of this paper. If only half of this quantity could be saved, this would amount to over ten million tons per annum, a substantial contribution towards the balancing of the coal gap in future years. That this saving can be achieved is evident from the fact that well-designed and well-operated boiler plant can and does operate at day-to-day efficiencies in the region of 80 per cent. The factors controlling boiler efficiency will now be examined and it will be indicated how the performance of the less efficient plants can be improved.

* Paper read before Section G of the British Association at Oxford on Thursday, September 2, 1954. (Abridged.)

† Of the British Coal Utilisation Research Association.

PLANT UNDER CONSIDERATION

Vertical boilers, Lancashire boilers, Economic (multitubular) boilers, and water-tube boilers are used in industry for steam raising. Although no precise statistics are available on the point, it is believed that most of the coal used (or abused!) by industry is in boilers of the Lancashire and Economic types. It is with these two kinds of boilers, therefore, that this paper is chiefly concerned.

A Lancashire boiler is generally about 30 ft. long and some 9 ft. in diameter. From end to end it is penetrated by two furnace tubes, each about 3 ft. in diameter. Coal is burned on grates occupying the first 6 or 8 ft. of the flue and the products of combustion flow towards the other extremity, where they pass downwards (through the "downtake" which may or may not contain a superheater) and then back to the front end by way of the bottom flue or "flame bed." Having reached the front of the boiler, the gas flow is divided into two streams, each of which passes along the outside of the boiler through the side flues. At the rear end of each side flue there is a damper for controlling the flow of gases through the boiler. Beyond the side flues the gases are passed to the chimney – in many cases through a heat exchanger, usually termed an economiser, which heats the feed water.

Economic boilers, although formerly some were placed in brickwork settings, similar to the Lancashire boiler, are now usually mounted on "cradles" on the boiler-house floor. Such boilers are referred to as "self-contained." The Economic boiler is shorter than the Lancashire boiler, though it may be somewhat larger in diameter. It may have one or two furnace tubes, two or three feet in diameter. The products of combustion from the grates pass down the furnace tubes and enter a chamber, generally brick lined, in which they are reversed in direction returning to the front end of the boiler through a large number (perhaps 100 or more) of smoke tubes of two or three inches diameter. They then normally pass out to the chimney via a control damper and perhaps an economiser. In this case the boiler is referred to as a "double-pass" Economic boiler. In other cases the gases, on reaching the front end, may again be reversed in direction and pass through another bank of tubes, when the boiler is known as a "treble-pass" Economic boiler. In either case it is possible, by the use of a large number of smoke tubes, to incorporate a great amount of heating surface in a relatively small boiler. For a given steam output the Economic is much more compact (and generally cheaper) than the Lancashire boiler.

Both Lancashire and Economic boilers, together with vertical, Scotch marine, Cornish and waste-heat boilers, are generally known as "shell boilers" – a term implying that the whole combustion process and heat exchange takes place within the boiler shell. Perhaps a more descriptive term would be "fire-tube boiler," since the fire is contained in, and the products of combustion pass through, the boiler tubes. This distinguishes it from the "water-tube" boiler in which the water is inside the tubes, combustion taking place externally to the boiler.

CAUSES OF INEFFICIENCY

There are four main sources of heat loss from boilers:—(*a*) The chimney gases; (*b*) combustible matter in ash and grit; (*c*) loss of unevaporated water from the boiler (blowdown); (*d*) loss of sensible heat from the boiler structure.

The relative importance of these losses may be judged from Table II. These figures mean that with the badly-operated plant, double the amount of fuel will be required to raise the same

TABLE II.—*Percentage of Heat Supplied to Boiler Lost through Various Channels*

Source of Loss	Loss: Percentage of Fuel Fired	
	Good Operation	Bad Operation
(*a*) Chimney gases	15·0	35·0
(*b*) Incomplete combustion of fuel	2·0	10·0
(*c*) Loss of unevaporated water (blowdown)	0·5	5·0
(*d*) Loss of sensible heat from boiler structure	2·5	10·0
(*e*) Total losses = $a+b+c+d$	20·0	60·0
Efficiency = $100-(a+b+c+d)$	80·0	40·0

amount of steam as in the case with the well-operated plant. It will be seen that in both instances the most important item is the loss in the chimney gases, which will now be discussed in more detail.

CHIMNEY GASES

The amount of heat contained in the gases is equal to the sum of the sensible heats of the different gases present, the latent heat of condensible gases, and the potential energy in combustible gases and smoke particles. The sensible heat of each of the various gases present is the product of its mass, specific heat, and temperature (above an accepted datum). The flue gas usually contains oxygen, nitrogen, carbon dioxide, and small amounts of carbon monoxide, methane and hydrogen. The sum of the sensible heats of the gases (excluding the total heat of the water vapour) is generally referred to as the "dry gas loss." The latent heat of the water vapour, together with its sensible heat in most cases where coal is burned, represents some 5 per cent. of the gross calorific value of the fuel fired. The potential energy of the combustible gases and smoke particles should be negligible (perhaps 0·01 per cent.), but may exceed 10 per cent. of the heat supplied when heavy smoke is being produced.[3] Table III analyses these losses for good and bad conditions of operation.

TABLE III.—*Analysis of Chimney Gas Losses expressed as a Percentage of Heat Supplied*

Source of Loss	Loss: Percentage of Fuel Fired	
	Good Operation (Clear Stack)	Bad Operation (Heavy Smoke)
(*a*) Dry flue gases	10	17
(*b*) Heat in water vapour	5	5
(*c*) Unburned combustible gases	Negligible	12
(*d*) Smoke particles	,,	1
Total	15	35

The kind of inefficiency depicted in the last column of Table III is the result of poor mixing between fuel and air, more especially between the volatile constituents of the coal and air. In practice it means the lack of secondary air in the right place and, on the all too visible evidence of heavy smoke production, is a quite common but unnecessary occurrence. It is possible to obtain a similar order of loss by supplying too much air, and while the heavy losses due to incomplete combustion disappear, they are replaced by an increased dry-gas loss as Table IV shows. Table V is another example of how the chimney gas loss may be made up, in a case where both the effects of mal-operation so far discussed, heavy smoke and excessive dry flue-gas loss, are present together. Such cases are extreme, but are known to occur quite often. The last column of Table V shows that whatever the other losses from the boiler may be, no less than 43 per cent. of the fuel fired is wasted up the chimney. The first column shows what good operation can achieve with the same boiler: a difference in boiler efficiency of 28 per cent.

It has, so far, been shown that the chimney

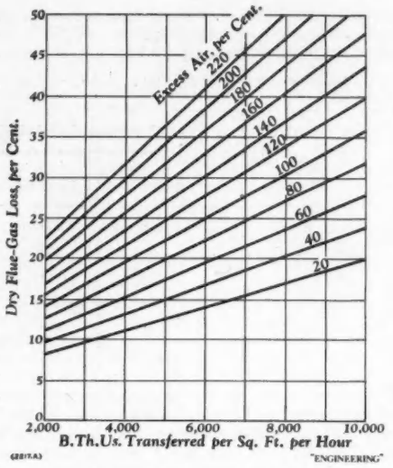

Fig. 1 Dry flue-gas loss regression.

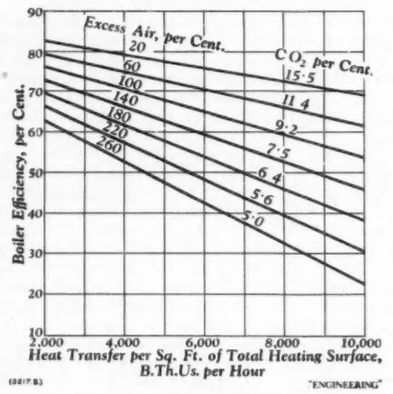

Fig. 2 Effect of excess air and heat transfer rate on boiler efficiency.

loss is normally the most important loss from a boiler, and that the sensible heat in the dry gases and the heat potential in the unburned combustible gases are its chief components. Further consideration will be given to these items in the remaining sections of this paper, while the other losses summarised in Table II, important though they may occasionally be, ought normally to be less significant; in any case the subject has been covered extensively in the literature.[4,5]

TABLE IV.—*Analysis of Chimney Gas Losses expressed as a Percentage of Heat Supplied*

Source of Loss	Loss: Percentage of Fuel Fired	
	Good Operation (Clear Stack)	Bad Operation (Clear Stack)
(*a*) Dry flue gases	10	30
(*b*) Latent heat of water vapour	5	4
(*c*) Unburned combustible gases	Negligible	Negligible
(*d*) Smoke particles	,,	,,
Total	15	34

TABLE V.—*Analysis of Flue Gas Losses*

Source of Loss	Loss: Percentage of Fuel Fired	
	Good Operation (Clear Stack)	Bad Operation (Heavy Smoke Production and Undue Excess Air)
(*a*) Dry flue gases	10	30
(*b*) Latent heat of water vapour	5	4
(*c*) Unburned combustible gases	Negligible	8
(*d*) Smoke particles	,,	1
Total	15	43

SENSIBLE HEAT IN DRY FLUE GASES

The gases present in the chimney comprise the following: carbon dioxide, water vapour (superheated), nitrogen, oxygen, carbon monoxide and perhaps small percentages of hydrogen and hydrocarbons. Assuming these gases to be well mixed, they will all be at the same temperature. Each component will contain sensible heat equal to the product of its mass, its temperature (above that of the ambient air) and its specific heat. Conveniently, the loss can be expressed in terms of thermal units per unit of time. Temperature and mass per unit of time are the most variable of the quantities, and in any case the specific heat cannot be deliberately controlled. It follows that the greater the rate of flow of chimney gases, and the higher their temperature, the greater will be the heat loss in these gases. Two important items which control the efficiency of the boiler are, therefore, the mass flow of the products of combustion and the temperature at which they leave the boiler. To minimise these quantities, therefore, is to obtain a greater boiler efficiency, and the steps which can be taken to do this will now be considered.

The Mass Flow of Products of Combustion.—A pound of coal requires, theoretically, about ten pounds of air to burn it completely. Imperfections in the combustion appliance and in its operation result in more than this quantity being supplied if heavy smoke production and unburned carbon in the ashes are to be avoided. In well-designed and well-operated plant, not more than 14 lb. of air per lb. of coal (40 per cent. excess air) need be used, but all too frequently it is found that 20 or 30 lb. are being used. In a normal Lancashire boiler burning 1,500 lb. of coal per hour, therefore, as much as 20 tons of air may be used in this time. The volume of this air is some half a million cubic feet. This means that whereas the mass flow of products of combustion need only be 15 lb. per lb. of coal, it may in fact be 20 or 30 lb. per lb. of coal, which has a proportionate effect on the dry-gas loss. It is, therefore, necessary to control the amount of air per lb. of coal fired as a first step in minimising the dry-gas loss. Various methods of doing this will be discussed later, but it must be emphasised that before any quantity can be controlled, it must first be measured, either by direct or indirect methods.

Boiler Exit Temperature.—When a solid fuel burns, the rise of temperature in the fuel is governed by the rate of heat generation within the fuel bed and the rate of transmission of heat from it. Some of the fuel is gasified, to complete its combustion above the fuel bed, and attains a temperature again determined by the rates of evolution and transmission of heat. The greater the temperature developed the greater will be the rate of transmission of heat, whether by radiation (which is governed by a fourth power law) or convection (which is linear with respect to temperature) and, for a constant condition of gas flow and a given heating surface, the greater the heat transfer in the boiler. The greater the amount of heat transmission by the gases inside the boiler, the lower will be their thermal content on leaving the boiler; the lower will be the dry flue-gas loss; hence the higher the efficiency. It follows then that other factors remaining unchanged, the higher the temperature of the gases emanating from the fuel, the more efficient will be the boiler. The amount of heat removed from the hot gases and fuel bed is also dependent on the ability of the heat receiving surfaces to pass this heat to the water in the boiler. Dirt and scale, more particularly on the gas side, will impede this heat transfer, raise the temperature of the gases leaving the boiler and reduce its efficiency.

From a given heat source, the quantity of heat received by a nearby surface will depend on the extent of that surface; the greater its area, the greater will be the heat absorption, and the lower will be the temperature of the gases after passing over the surface. Increasing the heat supply to the surface can increase the heat transferred by reason of an increase in temperature of the source and by increased gas velocity over the surface. If the temperature does not increase with the rate of heat supply, then the heat transfer to the surface will only increase as a result of an increase in gas velocity over the surface.

The law relating heat transfer by convection from a moving gas stream to the surface over which it is flowing is known to be of the form:—

$$dH = \frac{k\ dA\ G^{0.8}}{D^{0.2}} (t_1 - t_2) \quad . \quad . \quad (1)$$

where,

dH is an increment of heat transfer over an element of surface area, dA.
G is the rate of mass flow per unit of cross sectional area of any particular gas passage in the boiler of the gas over the area, dA of diameter D.
t_1 is the temperature of the heat source.
t_2 is the temperature of the heat receiving surface.
k is a constant depending on the density, viscosity and thermal conductivity of the gas.

The mass flow G of the gas is directly proportional to the rate of burning of the fuel, i.e., to the rate of heat supply.

Hence, for a particular gas passage

$$\frac{dH}{dA} = kG^{0.8} = k'Q^{0.8} \quad . \quad . \quad . \quad (2)$$

where,

Q is the rate of heat supply, and
k' involves k and the constant proportionality between Q and G.

Each different gas passage in the boiler can be treated in similar fashion. This means that an increment of heat transfer requires a more than proportionate increase in heat supply; in other words, boiler efficiency decreases as the rate of heat transfer per unit of area of heat-receiving surface increases. Assuming that the rate of gas flow remains unchanged, this decrease in efficiency must correspond to an increase in the boiler exit gas temperature. This statement assumes that the temperature of the heat source does not increase as a result of increasing the heat supply. Certainly under ideal conditions this must be true since the theoretical flame temperature sets an upper limit which cannot be exceeded, and rarely, if ever, achieved.

That this argument holds true in practice can be shown by experiment, and the evidence for it goes back over many years. Recently, however, the British Coal Utilisation Research Association have analysed a considerable number of boiler tests with a view to determining the essential elements which control boiler efficiency. An account of this work and the conclusions arising from it will be presented in this paper. Meanwhile, it has been shown that the following items are important in controlling the dry-gas loss which, it is suggested, is the most important component of boiler inefficiency.

Amount of Air used per Pound of Fuel.—A certain quantity above that theoretically required for complete combustion must be provided in practice. This excess quantity is generally referred to as "excess air," and is expressed as a percentage above that theoretically required.

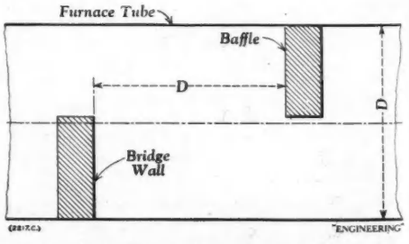

Fig. 3 Baffle fitted in furnace tube of Lancashire boiler to prevent accumulation of soot.

Temperature of the Gases Leaving the Boiler.—It has been shown that this is reduced by generating the initial heat at a high temperature, increased by the fouling of the boiler heating surfaces, and increased with the rate of heat transfer to the boiler heating surface.

In connection with the second group of factors, little can be done about controlling the temperature of initial heat release, since this depends on the nature of the fuel. Most fuels used in boilers seem to burn at somewhat similar initial temperatures which are probably of the order of 3,000 deg. F. Excess air, however, will cool the flame gases and will on that account lower the temperature of the initial heat release and thus tend to raise the boiler exit temperature, exercising, therefore, an adverse effect on boiler efficiency in addition to that of increasing the weight of gases passing out of the chimney. Boiler surfaces, however, can be kept clean, so that this factor will not be considered as a variable. The heat transfer rate per square foot of boiler heating surface has, however, been shown to affect the boiler exit temperature, and this can be controlled by using a large or small amount of heating surface to absorb a given amount of heat. Excess air and rate of heat transfer per square foot of heating surface appear, therefore, to be the main factors which determine the dry flue-gas loss and hence the efficiency of a boiler.

EXPERIMENTAL WORK

Extensive quantitative research work has been carried out over considerable periods by various organisations throughout the world. In recent years, the Fuel Research Station, working on Lancashire boilers,[5] and B.C.U.R.A., working on Lancashire and Economic boilers, have published much data[5,6] relating to boiler efficiency under various conditions of operation. Both organisations have demonstrated the separate effects of excess air and heat transfer in the boiler. The present paper gives a new appraisal of these data and the conclusions which arise from them.

The data referred to have been examined by B.C.U.R.A. using statistical methods, a regression equation having been derived relating dry-gas loss to heat transfer per square foot per hour and to excess air. The equation shown as a graph in Fig. 1 is as follows :

$$Lg = 4{\cdot}7 + 0{\cdot}115\,\frac{L}{100} + 0{\cdot}039E + 0{\cdot}16\,\frac{LE}{10^4} \quad . \quad . \quad (3)$$

where L is rate of heat transfer in B.Th.U.s per square foot of boiler heating surface; E is percentage excess air above that theoretically required; Lg is dry-gas loss expressed as a percentage of the gross heat supplied.

At first sight it might appear from this equation that boiler type was unimportant in determining boiler efficiency. Such a conclusion, however, might be misleading, since the normal working range of the Lancashire boiler is about L = 10,000 B.Th.U. per square foot per hour, and that of the Economic boiler is about L = 6,000 B.Th.U. per square foot per hour, i.e., the data are discrete. It may, however, be said that, because of the difference in heat transfer per square foot, the variations in efficiency occasioned by the difference in design are small enough to make it convenient to represent both boilers approximately by one equation. Further, it may be concluded that in boilers of these types, the most important factors in determining efficiency are operational, namely, the heat transfer per square foot and the excess air.

It is now possible to derive a further equation directly relating boiler efficiency to excess air and rate of heat transfer per square foot per hour. Certain limitations have to be imposed on other losses, however, as follows: (i) the loss due to latent heat of water vapour should be within the range constant at 4 to 6 per cent.; (ii) the losses from the boiler surface should correspond to those from a well-lagged boiler, which means that they should amount to 1 or 2 per cent. at full boiler load; (iii) the total loss due to unburned fuel should be about 2 per cent. (this figure should not be exceeded provided a good firing appliance is using a reasonably good fuel). The new equation is:

$$\eta = 86{\cdot}8 - 0{\cdot}00139L - 0{\cdot}0531E - 0{\cdot}000014LE \quad . \quad . \quad . \quad (4)$$

where η is boiler efficiency (per cent.) by difference and the other symbols are as for equation (3).

This equation is plotted as a graph in Fig. 2, and it will be noticed that (i) increasing the load (rate of heat transfer) on the boiler will decrease the efficiency; the effect being more important at high percentages of excess air or, alternatively, the adverse effect of excess air is less at low rates of heat transfer than at high rates.

It follows from this that when a boiler is being "forced" it is particularly important to maintain good combustion, otherwise a very low efficiency will be obtained. In practice, it can happen that in such circumstances it is impossible for the fireman and firing appliance to handle all the coal and ash required to obtain the output, so that the boiler will fail to meet the load for which it was intended, not because it is a bad boiler, but because it is being badly operated. Conversely, when a boiler is carrying only a light load (i.e., a low rate of heat transfer), some liberties can be taken with the combustion without such a great sacrifice in performance.

Thus a boiler which is large in relation to the heat demand from it will yield a fairly good efficiency, in spite of poor operation. It is often wise, therefore, when stand-by boiler plant is available, to bring it into operation so as to provide additional heating surface and thus reduce the average rate of heat transfer over the whole plant. Coal will generally be saved to a worthwhile extent by doing this, and conversely may be wasted by laying-off a boiler, when at first sight this procedure may suggest greater economy. Occasionally, particularly with single-shift operation, this course of action may fail to bring benefit owing to the necessity for supplying the surface heat losses from a greater number of boilers during idle periods, but it would seem to offer possibilities of saving fuel in a great many cases in industry.

The relationship given above can be used as a yardstick for all types of shell-boilers, but tends to give an efficiency on the low side for boilers where the gas velocity is very high, as is the case with "high velocity" and "treble-pass" Economic boilers. Even so, the deviations should be consistent. If serious departures from it are found to exist, the following troubles can be suspected: (i) If measured efficiency greatly exceeds that calculated from equation (4), wet steam is probably being generated. This should be corrected by seeing that the boiler is not being grossly overloaded and by attention to the density of the water in the boiler. (ii) If measured efficiency is much below that calculated, the heating surfaces may be fouled, or the coal not being properly burned off on the grate. Smoke and unburned combustible gases may also be present in the flue gases. Both statements assumed that the "measurement" of efficiency is accurate and that the instruments in use are reading correctly. A somewhat similar graphical relationship between boiler efficiency and heat transfer per square foot of heating surface per hour to that shown in Fig. 2, was obtained by William Kent[7] over 50 years ago in the United States. Kent's work was largely based on theoretical assumptions made by Rankine. One essential feature of both the theoretical and experimental aspects of the work is that they show that under the right conditions, boiler plant can operate at an efficiency of 80 per cent. or more. These "right conditions" can be achieved in industry and are in fact obtained in well-operated boiler houses.

CONTROL OF BOILER EFFICIENCY

It has been shown that both in theory and practice, excess air and rate of heat transfer per square foot of heating surface are the most important factors determining boiler efficiency. It now remains to consider how best these factors can be controlled in actual installations. Before control can be exercised, the factors it is desired to control must be measured directly or indirectly. This means that both excess air and heat transfer per square foot of heating surface must be measured. It is comparatively simple to derive both these by reliable and robust instruments, but such instruments are conspicuous by their absence in most industrial boiler houses. Orifice meters or Venturi's can be used to measure steam and air flows, although the pressure drop through the gas passes of the boiler is often used to measure the latter. Combined instruments recording steam flow and air flow are available and can be so designed that the respective pens or indicators coincide when the air flow has been correctly controlled either automatically or by the boiler operator.

It has already been suggested that about 14 lb. of air are sufficient, in practice, to burn a pound of coal. An instrument such as that mentioned above can be set so that this ratio of air to fuel is achieved when the pens or indicators are coincident. The boiler operator can then be trained to manipulate his air controls to maintain this coincidence, and, should he find difficulty in achieving this, to report the matter to a higher authority, when his trouble can be investigated and remedied. Another approach is to measure the excess air by measuring the dilution of the products of combustion. This can be achieved by the automatic determination of either the CO_2 or O_2 concentration in the flue gases by means of suitable instruments. The method involves sampling the flue gases, in itself a difficult

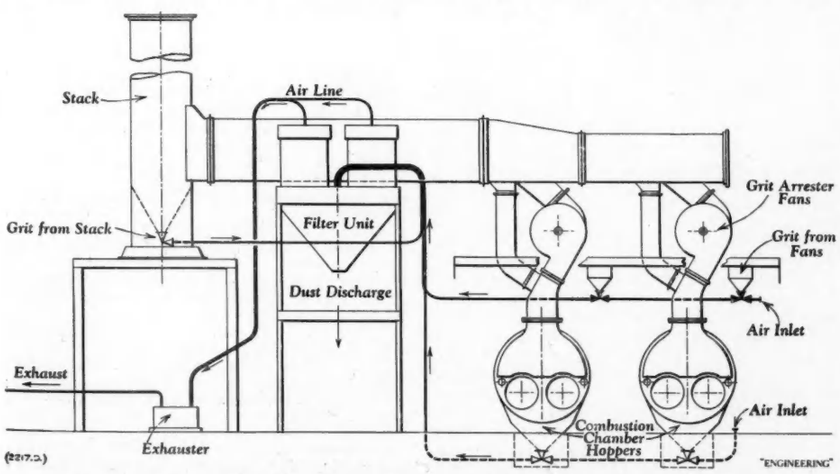

Fig. 4 Vacuum-cleaning installation for Economic boilers to remove tube deposits.

technique, and complicated by corrosion and blockage of the connecting pipework. One instrument measures both CO_2 and boiler exit gas temperature and ingeniously works out the dry flue-gas loss automatically by means of a nomogram.

AUTOMATIC CONTROL

Automatic control of large boiler plant has been practised for many years, but it is only fairly recently that it has penetrated into the smaller industrial boiler house, where, if properly applied, it can do much good. It is a little surprising that more use has not been made of automatic systems, since they have proved their worth and reliability over many years under even more arduous conditions than those existing in boiler houses In essense, such a system often uses the measurement of steam flow from the boiler, the signal then being amplified to a sufficient extent to operate the dampers controlling the air flow through the boiler. This air flow, in turn, can be measured and used to control the fuel flow to the firing appliance. Such systems and variations of them are commercially available at a cost not greatly exceeding that of the more orthodox instrumentation involving indicators and recorders.

The more extended use of automatic control would free the boiler operator from the minute-to-minute control which his plant requires, and enable him to concentrate his efforts on plant maintenance, the keeping of records, boiler water conditions and other essential duties which are at present either left undone or only inadequately carried out. All this is in addition to greater economy in boiler operation, and a more satisfactory steam service to the works, by reason of the steady steam conditions attained.

Recently a simple system of automatic control commercially available, has been applied to the firing of four Economic boilers serving a well known mental hospital, under the instruction of engineers of the Ministry of Works. The steam generated heats the buildings and serves the laundry and other steam-using services, so that the load imposed on the boilers is by no means steady. Engineers from the Ministry of Fuel and Power carried out tests with this plant to compare its performance under automatic control with manual control assisted by recording instruments and under good supervision. The improvement in efficiency was about 3 per cent., meaning a saving of about 4 per cent. in coal consumption. It must be mentioned that this saving was achieved even though the installation when manually controlled was particularly well supervised. When it is remembered that many boiler houses in the country lack both instruments and good supervision, it will be appreciated that the use of automatic control offers very great potentialities in attaining industrial fuel efficiency.

KEEPING HEATING SURFACES CLEAN

The boiler heating surface offers a resistance to the heat flow to the water in the boiler. Various factors can increase this resistance, so that less heat will be extracted from the fuel and more will remain in the flue gases leaving the boiler; in other words the temperature of the gases leaving the boiler, and hence the dry flue-gas loss, will be increased.

Water-Side Deposits.—Scale, composed of insoluble salts deposited from the water in the boiler as it becomes heated, will form on the water side of the heating surface and impede heat flow. Although the reduction in heat flow so caused may not affect significantly the heat extraction within the boiler and hence the efficiency, it may cause the temperature of parts of the metal structure of the boiler to increase to such an extent as to result in mechanical failure of the plant. Hence it may be necessary to treat the feed water to prevent any scale being formed.

Gas-Side Deposits.—Dust and soot which settle out on the gas side, while protecting the metal surface from overheating, may cause a serious reduction in heat absorption, amounting to six or seven per cent. of the heating value of the fuel fired, which is equivalent to a rise in exit-gas temperature of several hundred degrees Fahrenheit. It is important, therefore, to take steps to keep the heating surface clear of such deposits. These measures are not as a rule taken in industry, although in present day circumstances their use is on the increase. Manual cleaning of the boilers after several weeks on load is not good enough, and is likely to cause fuel wastage of several per cent.

There are three main methods of cleaning the gas side of the heating surfaces.

Soot Blowers.—These consist of steam or compressed-air jets arranged inside the combustion space and flues of the boiler. They are usually fixtures but capable of manual control of direction. Such a system may be applied to a Lancashire boiler, but other systems may be effectively used with Economic boilers. An innovation, particularly suited to multitubular boilers, such as Economic, locomotive and waste-heat boilers, is the percussion lance. This is a portable tool which discharges compressed air or steam in rapid pulses which have a great disrupting influence on the dirt deposits.

Baffles.—Baffles may be placed in the furnace tubes of boilers so as to deflect the gases to the region of the furnace tube where deposits are most likely to occur, namely, at the bottom. Fig. 3 shows a section of the furnace tube of a Lancashire boiler with such a baffle fitted. The dust particles are prevented from accumulating by the higher gas velocity and are carried out of the furnace tubes and re-deposited in the bottom flues, where they settle out on brickwork and have no harmful effect on heat transfer. Baffles are effective except where the dust fuses at a low temperature when, due to sintering, the deposits will gradually build up. A considerable amount of investigation of the effect of baffles has recently been carried out in Oxford.[8]

Vacuum Cleaners.—Vacuum cleaning equipment may be used to draw dust from key positions in boilers. Such equipment may be of a simple portable variety, but with adequate capacity for the large amounts of dust which may be handled, or may be static on the plant for which they are used. One cleaner may be fitted up to a large number of individual boilers. Vacuum-cleaning equipment, applied to a pair of Economic boilers, is illustrated in Fig. 4. Such arrangements might well be used in conjunction with baffles such as mentioned above. It should be noted that, in order to avoid nuisance from grit emission from the chimney when operating soot blowers or percussion lances, some precautions should be taken to prevent the dirt dislodged from being carried up the stack. Grit arresting, or precipitating or washing chambers, should be installed.

THE TRAINING OF FIREMEN

Boilers, and the combustion of fuel are subject to the known laws of science. Less restrained, but at least equal in importance, are the human difficulties met with. Boilers are under the control of operators who are supervised perhaps by a foreman who would be instructed in turn by a works engineer coming under higher executive authority. The operation of a boiler is not a labourer's job, and the unintelligent handling of such plant can turn it into a lethal weapon. While disasters due to boiler explosions are fortunately rare in this country, it should be remembered that the fireman is the man on the spot who, if he neglects his task, can be the instrument of very great damage. A fireman may also handle many thousands of pounds worth of fuel in a year. It is, therefore, necessary to ensure that the actual operator of the boiler is trained in the essential principles of his job. The Fuel Efficiency Committee of the Ministry of Fuel and Power have been actively interested in achieving this object, and their pioneer work has resulted in the City and Guilds of London Institute conducting, in 1953, their first examination for a Boiler-Operator's Certificate. There were over 100 entrants, and this year, it is expected, there will be over 1,000. Training for this examination (which involves practical tests as well as written papers) is being provided by technical colleges and where advantage cannot be taken of such facilities, correspondence courses are available.

The British Electricity Authority have their own training establishments; the boiler operators receive practical instruction on the plant they control and in addition, may volunteer for a course, usually lasting two weeks, at a residential training establishment. This scheme has now been in operation for a number of years and, it is held, has met with considerable success. The N.C.B. have also initiated a training scheme which is proving very valuable. The training of firemen could be the means of achieving a great reduction in industrial fuel consumption, but the incentive must be provided for the man, and this can only be in the final form of hard cash.

The implementation of such a training policy is the business of higher management who are unlikely to carry it out unless they are convinced of the need for doing so. This means education of another kind to convince industrialists of the essential needs for conserving fuel, and it is not easy to do this when in many cases the fuel bill may be only a few per cent. of the total turnover of the business. Moreover, the purchase of new boiler-house equipment, which may in itself bring about a return of capital in a very short time, has not, in the past, been encouraged by the Treasury, although recently such purchases have been rendered more attractive by the provision of substantial interest-free loans for approved fuel-economy schemes.

CONCLUSIONS

The following are the essential requirements for efficient steam raising.

(i) The boiler plant must be brought up to a good standard of maintenance. Air leakages must be sought for, and then sealed. Insulation must be renovated and all controls made easily operable.

(ii) A modern and controllable firing appliance must be fitted, which will give smokeless combustion with a minimum of grit emission over a wide range of burning rates.

(iii) A check should be made to see that adequate heating surface in the form of boiler surface, economiser surface, and perhaps superheater and air-heater, are installed. Reference to Fig. 1 will indicate that difficulties experienced at heat transfer rates of 10,000 B.Th.U.'s per square foot per hour would be greatly alleviated by increasing the heating surface to give only 6,000 B.Th.U.'s per square foot per hour.

(iv) Instruments to measure efficiency must be installed. These can be steam meters and coal meters as a minimum, but it has been shown that automatic control is available and has great advantages.

(v) Boiler heating surfaces must be kept clean.

(vi) All grades of persons responsible for boilers must be informed about their respective jobs. There is now no lack of educational facilities for this.

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VEHICLE CHARACTERISTICS AND ROAD ACCIDENTS*

EFFECTS OF DESIGN AND MAINTENANCE

By G. Grime, O.B.E., M.SC.†

Road safety, like peace, is indivisible, in the sense that there is no one best line of attack on the problem of safety. The education of road users, the building of better roads, and the improvement of vehicles must all go on together if best results are to be obtained; the fact that this paper is concerned only with the vehicle does not imply any doubt of the importance of the road or the road user. Vehicles can be made safer to drive in two ways: (1) by improving their design, and (2) by keeping them in better condition throughout their lives. In the present paper, after a brief review of evidence of the influence of vehicle characteristics on accidents, I shall endeavour to indicate the directions in which designs might be improved, to summarise evidence on the condition of vehicles in use on the roads, and to suggest methods of fostering good design and maintenance.

INFLUENCE OF VEHICLE DESIGN AND MAINTENANCE ON ACCIDENTS

Vehicle Type.—It is interesting first to consider the results of differences in vehicle design of the most fundamental kind, that is, between vehicles of different types. Table I gives the relative accident rates of vehicles of different types, expressed in terms of the relative numbers of

TABLE I.—*Relative Accident Rates per Vehicle-Mile of Different Types of Vehicle involved in Personal Injury Accidents in* 1950
(Cars and Taxis = 1·0)

Type of Vehicle	Relative Accident Rate	
	In built-up areas	In rural areas
Pedal cycles	2·4	4·4
Motor cycles (solo)	4·2	5·8
Motor cycles (combination)	1·6	2·6
Cars and taxis	1·0	1·0
Goods vehicles	0·9	1·1
Public-service vehicles	1·7	1·0

accidents per mile involving personal injury, either to an occupant of the vehicle or to some other road user. It illustrates how the protection afforded by the larger vehicles and the better stability of the four-wheeled vehicle result in lower accident rates. The same point is shown even more clearly by Table II; this contains data from collisions between two vehicles one of which was a car, and gives the number of drivers of other vehicles injured for every one car driver. The ratios range from 300 for pedal cyclists to 0·1 for drivers of public service vehicles. The major factors of design, the weight of the vehicle, the number of wheels, the degree of enclosure of the occupant, do therefore make an enormous difference (3,000 to 1) to the risk of personal injury in a collision. It will be

TABLE II.—*Relative risk to a driver of being injured in a collision with a Private Car*
(The ratio $\frac{\text{Other drivers injured}}{\text{Car drivers injured}}$ in two-vehicle accidents in 1951)

Other driver	Ratio
Pedal cyclist	300
Motor cyclist	50
Car driver	1·0
Goods driver	0·3
Driver of public-service vehicle	0·1

* Paper entitled "The Relationship between Vehicle Characteristics and Road Accidents: Effects of Design and Maintenance on Road Safety" read before Section G of the British Association at Oxford on Thursday, September 2, 1954. (Abridged.)

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surprising, therefore, if it is not possible to effect some improvements. Yet another broad relative comparison of vehicle types may be made by considering how lethal they are to pedestrians. Table III gives the ratio of injuries to deaths of

TABLE III.—*The Severity of Accidents with Vehicles of Different Types*
(From records of personal injury accidents involving one vehicle and a pedestrian in 1951)

Type of Vehicle	Ratio: $\frac{\text{Total No. of injured pedestrians}}{\text{Number of pedestrians killed}}$
Pedal cycles	85
Motor cycles	37
Cars and taxis	30
Goods vehicles	17
Public-service vehicles	11

pedestrians in personal-injury accidents. As might be expected, the ratios appear to depend upon the weight of the vehicle involved, the heaviest being the most lethal.

Visibility.—Unquestionably, one of the most important requirements in driving a vehicle is a good all-round view. The effect of a general reduction in visibility on accidents can perhaps be best shown by comparing casualties in wet weather with those in dry weather. Smeed[1] has shown that in daylight when it is wet there is an increase of about 40 per cent. in adult pedestrian casualties; at night the increase is about 130 per cent. Some of this increase (about 16 per cent.) is due to skidding accidents, and some may be due to poorer seeing on the part of pedestrians, but a great deal must be due to the deterioration in the driver's view. The figure for the increase at night is particularly noteworthy. Table IV illustrates in another

TABLE IV.—*Effect of poor visibility on accidents in built-up areas in* 1952

State of Light	Percentage of accidents* which occurred in —	
	(*a*) Clear weather	(*b*) Rain or hail
Daylight	91	9
Dusk	84	16
Street lamps lit	79	21

* Accidents in snow, sleet, fog, mist and strong wind have been omitted from this comparison.

way the effect of poor visibility by considering the relative numbers of accidents in rainy weather and in clear weather in built-up areas in daylight, dusk, and with street lamps lit. The reduced visibility due to the rain has greatest effect in increasing accidents when superimposed on the already difficult lighting conditions resulting from the failing light of dusk, or the inadequate illumination of the average street-lighting installation.

I shall now give a few instances where known defects in the view from vehicles can with some plausibility be related to accidents.

Right-turning accidents.—Vehicles of different types have different probabilities of being involved in right-turning accidents; taking the accident rate for cars and taxis as equal to unity, other vehicle groups have the following relative accident rates: cars and taxis, 1·0, goods vehicles (under 1 ton), 1·5, goods vehicles (over 1 ton), 1·3, public-service vehicles, 1·0. (These figures were calculated by dividing the numbers of right-turning accidents in 1950 for the five groups by the estimated vehicle-miles, based on estimated fuel consumption, for the appropriate group. Alternative methods of estimation based on traffic counts suggest greater differences between goods vehicles and cars and taxis, so that the figures given are probably on the conservative side.) Goods vehicles have the highest rates; it will be shown later that they often have unsatisfactory rear-viewing arrangements. Public-service vehicles, which have a rate as low as that of cars, generally have well-placed off-side mirrors; their drivers may also be exceptionally skilful, and they will more frequently know the turning points on their routes.

Accidents to overtaking motor cyclists.—In about 70 per cent. of the right-turning accidents quoted above, the motor vehicle turned across a following motor cycle. A motor cycle is a small, rapidly moving object, easily overlooked by a driver about to turn. Better rear-viewing mirrors might have enabled some of these accidents to be avoided.

Left-turning accidents.—Calculations of relative rates per vehicle mile for left-turning accidents in 1950, give the following figures:—cars and taxis 1·0, goods vehicles (under 1 ton) 1·4, goods vehicles (over 1 ton) 1·5, public-service vehicles 0·6. Again, goods vehicles have the highest rates and public-service vehicles the lowest rates. The high rate for the heavier goods vehicles may perhaps be explained by their slow speed and low acceleration which allow vehicles, particularly bicycles, to overtake them unseen on the near side at traffic lights and at intersections in general; in such circumstances, a vehicle overtaking on the near side can only be seen if that in front has a near side mirror, which few commercial vehicles carry. Most of these accidents occur during daylight in built-up areas, when cyclists are numerous; it is therefore not surprising to find that in about 70 per cent. of left-turning accidents, the motor vehicle turned left across the path of a pedal-cyclist.

Turning accidents to cyclists.—Accidents to cyclists in 1949 in which the cyclist was injured by being hit in the side or rear provide the following comparison: cyclists turning right, 390, cyclists turning left, 19, cyclists going straight ahead, 755.

Right-turning accidents are therefore much more frequent than left-turning ones; clearly this is related to the difficulty of turning the body so as to see to the rear of a bicycle. Hardly any cycles carry rear-view mirrors.

Vehicle doors.—Three and a half per cent. of all personal-injury accidents to cyclists are due to collisions with vehicle doors. A better view to the rear from the vehicle might have prevented some of these accidents. Sliding doors would probably eliminate most of them.

Moving-off accidents.—The inability of the driver to see the ground very near to a motor vehicle either in front of it or to the rear is a factor in many accidents to young children. Figures are given in Table V. Almost all such

TABLE V.—*Moving-off Accidents Resulting in Fatal Injuries to to Children under* 15 *years of age*

Type of Vehicle	Number of Accidents
Goods	152
Cars	2
Public-service vehicle	1
Other	4

accidents involve commercial vehicles, probably because commercial vehicles do far more stopping and starting in built-up areas than private cars. One in five of the commercial vehicles was an electric vehicle, compared with one in 12 involved in all accidents to children under 5. These electric vehicles are probably used only for door to door delivery and as they start up silently, children playing near them get no warning. Two-thirds of the accidents occurred when the vehicles were moving forwards and an improved front design might eliminate many of these accidents. Providing a view underneath and to the rear is more difficult.

Rear lights.—Inadequate rear lights, by giving insufficient warning to an oncoming driver, are responsible for many night accidents. A statistical analysis was made for the period October to December, 1949, of two-vehicle accidents, in which one vehicle had run into the back of

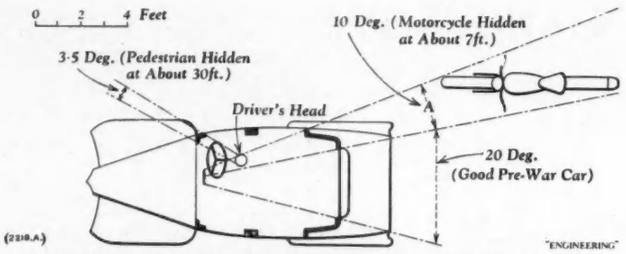

Fig. 1 Plan of private car showing obstructions to the driver's view. The angles are typical of present-day cars.

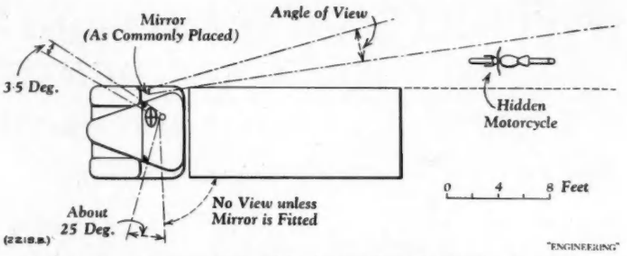

Fig. 2 Plan of commercial vehicle showing how the view to the rear is limited by the bodywork of the vehicle.

another. The results, which are given in Table VI in the form of ratios of accidents by night to those occurring by day, show that new cars (which have good rear lights conforming to American S.A.E. standards) were struck less

TABLE VI.—*Collisions in which one vehicle ran into the Rear of Another*
(*October to December*, 1949)

Type of Accident	Vehicle Hit	Ratio of Accidents at Night to those Occurring by Day	
		Old Vehicles (1930-1939)	New Vehicles (1946-1949)
Parked vehicle hit in rear	Private car ..	2·3	0·4
	Commercial vehicle	2·2	2·2
Temporarily held-up vehicle hit in rear	Private car ..	1·0	0·2
	Commercial vehicle	1·7	0·7

frequently by night than by day, but that commercial vehicles and old cars, which had poor rear lights, were struck more frequently. It was calculated that if all rear lights (including those on bicycles) were brought up to the standard of those on new cars, total road casualties in Great Britain would be reduced by about 2 per cent.

Stability.—Although the stability of the vehicle, which affects the ability to steer in the required direction, must be of considerable importance in accident situations, we can trace its influence only in skidding accidents. Table VII compares the liability of vehicles of different types to be involved in a skidding accident resulting in personal injury. The "skidding rates" given in the last column show that in relation to other types of vehicle, motor cycles have very high skidding rates; per mile travelled the frequency of motor cycle skidding accidents is eleven times that of cars and taxis. Pedal cycles too have high rates. In both cases the dominating characteristic is no doubt that of the lower stability of the two-wheeled vehicle.

TABLE VII.—*Vehicles Reported as Skidding in Personal Injury Accidents in* 1950

Type of Vehicle	Number of Vehicles skidding (dry, wet or icy roads)	Percentage of Vehicles of each type skidding
Motor cycles	4,949	10·6
Cars and taxis	3,606	4·4
Goods	2,030	4·2
Public-service vehicle ..	647	2·3
Pedal cycles	2,191	3·9
Other vehicles	272	2·7
All vehicles	13,695	5·0

Age of vehicle.—Age may be expected to result in general deterioration of the vehicle, and particularly of its brakes, steering and lighting. There are three pieces of evidence concerning the effect of this on accidents. (1) Investigations by the Laboratory have shown that although the older cars have about 25 per cent. fewer accidents per car, per year, they travel not more than one-half as many miles, and therefore have more accidents per vehicle-mile than the newer ones. (2) We have already seen that older cars, because of their poor rear lights are more frequently run into from the rear at night. (3) Table VIII compares the skidding rates of new and old cars. There is a tendency for the new cars to be more liable to skid, particularly on wet roads. This is perhaps because of their higher speed and better brakes.

TABLE VIII.—*Relation between Skidding Accidents and Age of Cars*

Year of first registration	Total number of cars involved in all accidents	Number of cars skidding / Total number of cars involved in accidents under the same condition of road surface × 100			
		Icy	Dry	Wet	All conditions
1936 or before	24,462	43	0·83	7·4	4·2
1937–9 ..	22,342	42	0·79	8·3	4·5
1940–5 ..	1,784	42	1·23	7·7	5·0
1946 and after	20,916	40	1·00	10·6	5·7

Fig. 3 Commercial vehicle with a curved wind-screen giving a wide angle of view in the forward direction.

IMPROVEMENTS IN DESIGN

Visibility.—We have seen that certain features of the design of vehicles can be linked, with some degree of certainty, with accidents. These design features are connected either with difficulties in seeing, or with instability on slippery roads. In the next section of this paper I shall endeavour to suggest where improvements in design are needed; it will not always be possible to establish a connection between the particular features of design, in which we are interested, and the incidence of accidents; we shall generally be able to show only how far the defects to which attention is drawn reduce visibility, or braking performance, or stability. We shall then make the common sense assumption that alterations to the vehicle which improve it in these respects will promote safety.

Bodywork and Mirrors.—To demonstrate where improvements are required to the driver's view, Figs. 1 and 2 have been prepared for a typical car and commercial vehicle. Both diagrams show that windscreen pillars are wider than is desirable and may conceal a pedestrian or cyclist. Pillars should be narrower than the distance between the driver's eyes (2 in. would be satisfactory). Curved windscreens have no value unless they enable pillars to be moved to give a wider view. This is only seen in certain commercial vehicles, of which an example is shown in Fig. 3. The rear windows of almost all current British cars are too narrow, and perhaps worse still, are too low. There is a large blind spot at A, in Fig. 1, in which an overtaking motorcyclist can be concealed. This blind spot can, of course, be eliminated by an external mirror; but only a re-design of the bodywork of the car can cure the rear window, which is so low that it does not allow an interior mirror to be placed to give a horizontal view out of the rear window. New cars are often worse in this matter of rear-window design than old ones. Figs. 4 and 5, for example, compare a pre-war car with its post-war successor.

The difficulty of providing a good view to the rear is even more pronounced for commercial vehicles than for cars. In the majority of such vehicles a view to the rear can only be obtained by means of external mirrors, the best of which leave the road immediately behind the vehicle invisible. Lorries with low bodywork, however, can be furnished with windows all round the back of the cab so that an internal mirror can be fitted. A good example is shown in Fig. 6. Counts on a main road in 1951 revealed that only 5 per cent. of commercial vehicles had these windows, but that about 30 per cent. could have used them. A common defect in the fitting of external mirrors, which has been observed in about two-thirds of commercial vehicles, is that the view is obstructed by bodywork or by the load (see Fig. 2), leaving a blind spot similar to that of the private car. On the left-hand side the driver of a commercial vehicle generally has no view at all unless he has a mirror on that side. Sixty to eighty per cent. of these vehicles have no mirror on the near side. Good practice is illustrated by the London 'bus, Fig. 7. We have already seen that 'buses have a good record for both right- and left-turning accidents.

Windscreen Wipers.—One of the most striking features of the data quoted in the last section is the increased number of accidents in rainy weather under conditions of difficult visibility. This

Fig. 4 Pre-war car.

Fig. 5 Post-war car.

Figs. 4 and 5 The view through the rear window of a pre-war and a post-war car of the same make and size. The photographs were taken through plane mirrors placed in the position of the driving mirror.

suggests that keeping the windscreen and the other windows clean by means of efficient wipers and de-misters may be of great importance to safety. Commonsense considerations also lead to the same conclusion; for if it is important to reduce the width of windscreen pillars from 3½ in. to 2 in., then it is probably of even greater importance to reduce the large area of windscreen obscured in wet weather, and to wipe it right up to the offside pillar. Fig. 8 is a diagram showing how this has almost been accomplished on one German car.

Direction Indicators.—Recent legislation permits flashing direction indicators to be used in this country and allows the rear indicator to be housed in the same housing as the stop light. Investigations by the Psychological Laboratory at Cambridge have shown that with this arrangement a following driver who sees the signal takes about half a second longer to act than if the rear indicator is clearly separated from the stop light. This is because he has to wait for the second flash before he is sure whether the signal is for a stop or a turn. Further consideration might usefully be given to where the new turning signals should be fitted.

Cycles and motor cycles have no windscreen pillars to block the view forward, but it is very difficult to see to the rear. This matters more for cycles than for motor cycles, since cycles are slower and, as we have seen, are liable to be run into when turning right. In the past it has not been considered feasible to use a mirror on a bicycle, both because of the awkwardness of stowing away a bicycle having a mirror sticking out sideways to the distance necessary for a good view, and because the mirrors available were liable to vibrate and so give a poor image. A mirror recently tested at the Road Research Laboratory avoids these difficulties (see Fig. 9); the supporting arm is pivoted and folds back when not in use and the arm and mirror are stoutly made and do not vibrate. Riders who have tried the bicycle on which this mirror is fitted are convinced of its value. The universal adoption of a mirror of this kind as a standard fitting on bicycles might well reduce cyclist casualties considerably.

Fig. 6 Lorry fitted with windows in the back of the cab so that, with the aid of an internal driving mirror, a good view to the rear is obtained.

Headlamps.—Up to the present I have dealt with matters which affect visibility both by day and by night. At night, however, probably the most important factor in promoting good visibility is the performance of headlamps, particularly under the critical conditions for seeing which occur when vehicles meet. A great deal is now known about the performances of headlamps, and, as the result of work at the Road Research Laboratory[2] and elsewhere, it is possible to state (1) no new system of conventional headlighting (similar to those now in use) is likely to give greatly improved results in the meeting situation compared with systems now being fitted to new cars, (2) between correctly adjusted examples of the two main types of headlamp in use, the European and the American (or British), there is little to choose, and (3) unless some radically different system of headlighting could be introduced (such as polarised lighting) far greater improvements would result from enforcing uniformity than by adopting any new design of lamp. I shall have more to say on this subject in the next section, which deals with maintenance.

Rear Lamps.—The influence which good rear lights have in reducing night accidents has been shown in the section on accidents. The " good " rear lights were ones which fulfilled the American Society of Automotive Engineers specifications on cars designed for the American export market. To find out whether this standard is excessively high for this country, measurements of visibility distances were made by an observer in a car moving at 30 m.p.h. The observer noted the instant when a rear light became (*a*) just visible, (*b*) just unmistakable as a red light, (*c*) just obvious, and (*d*) just brilliant. The observations were made in various weather conditions, with and without opposing glare, and for a range of intensity of the rear light. Observers were in agreement that, as drivers, they would be certain of taking action on the road when a rear light became just obvious. Fig. 10, on page 342, gives results when the opposing glare intensity is 5000 candelas, a value not unlikely to be met if headlamps are incorrectly aimed. A red rear light of 0·25 candela (the S.A.E. standard) is then just obvious at about 300 ft. This appears to be by no means an excessive warning distance in view of the number of vehicles on the road with poor brakes (see later section of this paper) and the conclusion was drawn that the American standard for rear lights was adequate but not excessively high.

Having established this standard of a quarter of a candela, a survey was made, in 1950, of numerous rear lights in London and the Midlands. It was found that three-quarters of private cars, commercial vehicles, public-service vehicles and motor cycles, and 98 per cent. of cycles had rear lights which are less bright than the 0·25 candela which is desirable; 80 per cent. of cycles and 60 per cent. of commercial vehicles had rear lights less than one-tenth of this brightness. In considering these results, it is not possible to separate the effects of low initial design requirements from those of deterioration, since the initial performance is not known. Since the results of this survey were obtained legislation has been passed which makes it probable that all mechanically-propelled vehicles will soon be equipped with good rear lights. All new cars

Fig. 7 A London bus, showing rear-view mirrors on both the near and off sides. About 60 per cent. of commercial vehicles have no near-side mirror.

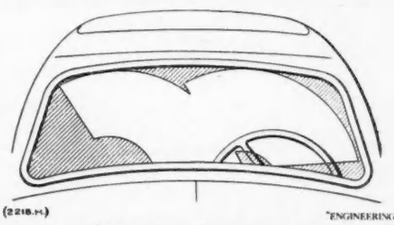

Fig. 8 Windscreen wipers arranged to wipe near the windscreen pillar, so minimising the amount of view obscured in wet weather.

are already so equipped, but it is probably even more important for slower vehicles, and particularly for bicycles.

Marker Lamps.—In the United States of America, all large vehicles carry groups of small identification lamps, facing forwards, which indicate the size of the vehicle. They may also carry side marker lamps which show up the vehicle from the side. Such lamps have been proved by experience to be valuable on American roads where speeds are higher than in this country. But the speed of our rural traffic is also increasing, and it appears very likely that such lamps would be of value here, too.

Brakes and Stability.—When new car brakes are generally satisfactory in respect of their stopping power in an emergency; some measurements by the Laboratory showed that in 1949 only 2 per cent. of cars less than three years old had brakes incapable of achieving an average deceleration of 13 ft. per second per second – a figure often taken as the dividing line between good and bad. Fig. 11, on the following page, compares the braking performance of vehicles of the various types, in

Fig. 9 Rear-view mirror for a bicycle. The supporting arm folds back when storing the bicycle and is sufficiently rigid that it will not vibrate and give a poor image.

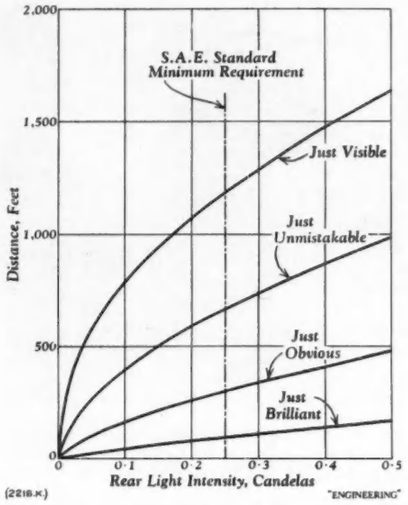

Fig. 10 Variation of visibility distance (using four standards of visibility) with rear light intensity for a prevailing glare intensity of 5000 candelas.

good condition. One of the main difficulties with new car brakes is to maintain the front-wheel brakes in proper balance. Tests by the Laboratory have shown that, whereas unbalanced brakes on the rear wheels have no serious effect on the driver's control of his vehicle, unbalance on the front wheels can easily make the vehicle swing completely round in an emergency stop, even from as little as 35 m.p.h. on a dry road. In normal travel, a driver rarely applies his brakes firmly, and is unlikely to discover how badly unbalanced his brakes are until he is involved in an accident situation. Improvements to front brakes are therefore a fruitful field for the designer.

As regards braking in general, the most sweeping improvement which could be made would be a device to prevent the locking of any wheel. As long as at least one wheel on each axle is rotating, some measure at least of steering control is retained, but when a wheel locks, it loses its significance as a wheel and can slide equally well in any direction. If both front wheels lock, all steering control is lost; if the rear wheels lock, the rear of the vehicle can slide in any direction. Furthermore, maximum braking is obtained when the wheel is just not locked. On the grounds, therefore, both of steering control and of maximum braking, a method of braking which would ensure that the wheels never locked would be a valuable contribution to safety.

A similar device for motor cycles would be even more valuable than for four-wheeled vehicles since the consequences of the loss of steering control can be so much more serious. Surveys by the Laboratory have shown that the brakes of most motor cycles are capable of locking the rear wheel and of nearly locking the front wheel. It is difficult, however, to use the available braking fully. There is a large weight transfer from the rear to the front wheel when a motor cycle is braked, and locking the rear wheel alone only gives a deceleration of $0{\cdot}35g$; the rest must come from the front brake. But if the front wheel is locked, the rider is almost certain to fall off. So the front brake is generally used cautiously; many riders never use it.

The brakes of light commercial vehicles are generally similar to those of cars and require the same improvement. The brakes of some of the heavier commercial vehicles are also of similar efficiency, but some, even when new, fall far short. Certain heavy vehicles (see Fig. 11) having power-operated brakes depending on compressed air or vacuum have very long stopping distances although the maximum braking force is quite high; this is because pressure builds up too slowly and the brakes take a long time to come on. There is no insuperable difficulty in eliminating this defect in power-operated brakes at the present day.

Design Changes to Protect Occupants.—I shall now consider those features of the design which affect the incidence and severity of injuries received in accidents by occupants of vehicles. For private cars, the subject has received a great deal of attention in the United States of America, where the occupants of private cars make up 75 per cent. of all deaths in road accidents. Work is in progress by the Indiana State Police in collaboration with Cornell Medical School, by the Institute of Transportation and Traffic Engineering, Los Angeles, and others. Similar studies have also been made in France[3]. The investigations have shown that the main cause of death and injury to the occupants of vehicles is not the breaking up of the structure of the vehicle, but the impact of the passenger or driver on the structure. In a head-on collision, for example, the vehicle is brought to rest in a matter of two feet or so, but the occupants continue to travel forward with undiminished speed, generally striking their heads on the windscreen or dashboard after it has come to rest.

The solution advocated by most workers in America is a safety belt to hold the driver or passenger in his seat. The Indiana State Police estimate that perhaps two-thirds of the deaths in crashes studied by them might have been avoided had the occupants of the vehicles been held in their seats by properly designed safety belts. A number of commercial firms fit safety belts in their cars, and the belts are on sale in the United States. Other conclusions are the following. (1) The doors of cars involved in collisions are frequently forced open by the impact and the occupants hurled into the road. Better door locks are advocated. (2) Skull, neck and chest injuries accounted for over four-fifths of the deaths, skull and neck injuries alone causing over one-half. (3) There is considerable scope for making the insides of cars safer by improving the design of steering-wheels, instrument panels and window frames, so that when the occupants strike these fittings, they are stopped with the least possible injury. (4) The anchorages of seats to the floor generally require strengthening. (5) Although high speeds increase the severity of crashes, severe injuries and death can occur in the same way in crashes at low speed as at high.

The American work makes it clear that, if a method acceptable to passengers and driver of holding the occupants of cars in their seats could be found, it would reduce the casualties inside these vehicles enormously. Failing this most complete solution, attention to doors and seats, and the redesign of the inside of the vehicle, particularly the instrument panels, windscreens, and the backs of seats to provide cushioning for the impact of the head might well effect a smaller but important reduction in casualties. Research on safety belts and similar devices is being actively pursued in the United States of America.

It is natural for American interest to be

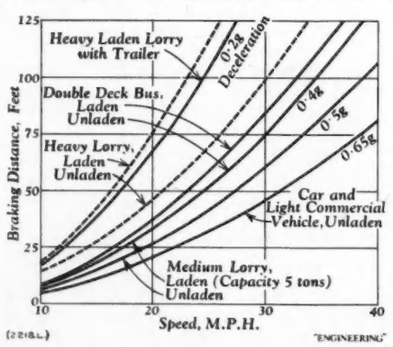

Fig. 11 Observed braking distances of vehicles of different classes having brakes in good condition and adjustment.

confined to crash injuries to the occupants of cars, since cycle and motor-cycle accidents are rare, but in this country both motor cycle and cycle injuries nearly equal in number those of the occupants of cars. It appears doubtful whether any major modifications are possible to bicycles to make them safer when an accident occurs but there are several possibilities for motor cycles. Unfortunately, there is a lack of well-ordered evidence as to how motor cyclists are most frequently injured but it seems probable that the increased likelihood of injury to riders of motor cycles arises from two main causes: (1) the lack of stability inherent in a two-wheeled vehicle compared with one which stays upright without a rider, and (2) the fact that in accidents the rider is nearly always flung from the machine and receives no protection from it.

Vehicles of the motor-cycle type are now coming on the market, however, in which one or both of these difficulties appears to have been overcome. The intention of the designer may not have been to provide greater safety, but more weather protection than is given by the ordinary motor cycle. In a fairly normal type of motor scooter now becoming popular there is much more protection for the legs of the rider than is provided by an ordinary motor cycle. This is important because leg injuries are the second most serious class of injury to motor cyclists. In a second type of motor cycle, Fig. 12, the rider is completely enclosed in a saloon body, and it appears likely that this bodywork would afford considerable protection to the rider, and in many accidents might prevent him from being thrown from his machine. Investigations might profitably be made to find the best method of strengthening the bodywork to afford maximum protection in accidents, and also to determine whether in such a machine the rider would be less likely to suffer injury if he were tied to his machine by a safety belt.

The orthodox type of motor cycle is more difficult to change in any way. Nevertheless, there may be advantages in enclosing even a normal motor cycle, apart from the extra weather protection and possible safety. Streamlined motor cycles have been used in recent successful record breaking attempts, and the possibility of enclosing normal motor cycles in this way is certainly worth investigation. It might perhaps be easier to make these changes to motor-cycle combinations.

Stability is the second probable factor in the high injury rate of motor cyclists. Several attempts have been made recently to produce really small three-wheelers which are little more than covered-in motor cycles with an extra wheel. They should not be confused with the larger three-wheelers which are to be classed with small cars. It is to be hoped that the development of these vehicles will continue.

NEED FOR IMPROVED MAINTENANCE

The need for improvements in the maintenance of vehicles is much more obvious than the need for improved design. Drivers on the road at night, for example, are continually being made aware of badly adjusted headlights. The results of several investigations by the Laboratory will now be given to show the unsatisfactory state of the maintenance of vehicles on the road, and to indicate where improvements are most urgently required.

Headlights.—Some years ago a series of "dazzle surveys" was made on trunk roads in several parts of the country. We noted the lights of every vehicle met and whether or not they were dazzling. It was found that if we excluded the quite large proportion of vehicles which were being driven on sidelights alone, then about 17 per cent. of vehicles met were dazzling. Most of the 17 per cent. was accounted for by dipped beams or the beams of passlamps or fog lamps – those extra lamps mounted below the headlamp level which are so frequently resorted to as a substitute for the dipped headlight. The undipped headlight was comparatively unimportant on busy roads. Although, because of their greater numbers, dipped beams

were more frequently a cause of dazzle than passlights, the passlight was actually the worse type. Twenty per cent. of passlights caused dazzle but only 10 per cent. of dipped headlights. We have also measured the intensity of the light received at the driver's eyes. Roughly 40 per cent. of meeting beams gave glare intensities of more than 2000 candelas, while from 5 to 9 per cent. gave more than 5000 candelas. The modern double-dipping headlamps as fitted on new cars are designed to give less than 2000 candelas under the conditions in which these measurements were taken. The causes which might lead to this diversity are fairly obvious. They are the use of different designs of lamp, different numbers of lamps (some vehicles use four), or defocused lamps, but above all mis-aim and deterioration of equipment. Some of these factors have been studied in a survey of about 800 vehicles, carried out in 1952 on a particular road in Oxfordshire.

It is convenient to consider what percentages of headlamps were aimed within ½ deg. and 3 deg. of the correct position. This includes side aim as well as up and down. Not more than 10 per cent. of the lamps were within ½ deg. of the correct position, while about 50 per cent. were more than 3 deg. out or were so badly defocused or deteriorated that it was impossible to estimate their aim with any degree of accuracy. This angle of 3 deg. was chosen because it is a familiar angle in headlighting practice; it is the angle between the main and dipped beams of an ordinary dipping headlight. Passlamps are particularly badly aimed. Because they are mounted low they are not exempt from the rule that a meeting beam must be dipped. They should be dipped about 3 deg. like the dipped beams from headlights. At least half of them were dipped less than 2 deg. and from one sixth to one third were pointing above the horizontal. Fixed headlights also showed the same faults.

An interesting point in connection with lamp design was found by comparing the results for the different types of lamp on cars. The modern flush-mounting lamps had almost four times as large a proportion within ½ deg. of the correct aim as the stem-mounted lamps, and this was not simply due to the fact that these cars and lamps were newer. While mis-aim can give rise to very high or very low intensities, deterioration always gives rise to low ones. The dipped beam from a headlight generally has a maximum intensity of 10,000 candelas or more when new and this is aimed about 3 deg. down, hitting the road at 50 ft. or so in front of the car. It was found that 16 per cent. of cars using the dip and switch method (mostly pre-war cars) had maximum intensities of less than 1000 candelas in the dipped beam instead of at least 10,000 they once had; 52 per cent. had maxima below 5000 and 76 per cent. less than 10,000. Somewhat similar figures were found for passlights.

These surveys have shown that mis-aim and deterioration are so prevalent that it is not surprising that complaints about dazzle on the roads are constantly being made. When users of poor lights meet vehicles with lamps in good condition they are almost certain to be dazzled, but unless at some time they have driven with good lights they may not realise how much they themselves contribute towards this result. Even when the road is clear of other vehicles these lamps give a reduced range of vision and may contribute towards an accident.

As a result of these surveys and of other tests, the Laboratory has put forward suggestions for securing greater uniformity in vehicle headlights. They are as follows:

(1) The standard of headlight aiming should be improved and a set of rules in which correct aiming is defined should be drawn up.

(2) The intensity of meeting beams should fall within certain limits. This would eliminate both the feeble and the excessively bright lights.

(3) Steps should be taken to secure a high degree of conformity with the standards of aiming and intensity.

(4) New headlamps should all have beams giving the same distribution of light. The beams given by the double-dipping lamps now fitted to most new cars might form the basis of a suitable specification. Subsequent experience and research may be expected to show that some improvements can still be made.

(5) Attention should be given to the lights on motor cycles. They require similar treatment to car lights but probably need a beam of a slightly different pattern.

The indications from the surveys are that headlights in use today are so badly aimed and maintained that a far greater improvement could be obtained by bringing these lamps into a good state of aim and efficiency than by any alteration to the design of the lamp.

Brakes.—With the co-operation of the Police, the braking performance of a random sample of vehicles in use on the roads has been measured with decelerometers which measured the maximum deceleration achieved in braking from about 20 m.p.h. The decelerometer reading expresses the force retarding the vehicle in terms of the weight of the car. Thus a reading of 1/5th gravity or $0{\cdot}2g$ means that this force was 1/5th of the weight of the car.

The most important results were:—

(1) 1 per cent. of a random sample of cars and commercial vehicles did not attain a maximum deceleration of $0{\cdot}2g$ and 12 per cent. did not attain $0{\cdot}4g$. The corresponding distances required to stop from 30 m.p.h. on a level road were estimated to be about 200 and 100 ft. respectively, excluding the distance travelled during the reaction time of the driver. (See Table IX). Going down a hill with a slope of 1 in 10 – a not very uncommon slope – the corresponding distances would be approximately 400 and 135 ft. respectively.

(2) On the average, the older the car or commercial vehicle, the lower was its braking performance. Of the cars which were less than two years old, only about 1 per cent. did not achieve a maximum deceleration of $0{\cdot}4g$. About 7 per cent. of the commercial vehicles less than two years old were unable to reach this figure.

(3) Practically all motor cycles tested could lock the rear wheels; almost none the front wheel.

To appreciate the significance of the results obtained in tests on vehicles in use and to study the factors affecting braking performance, a series of experiments was carried out on vehicles having good brakes. It was found that the

TABLE IX.—*Results of Brake Tests on Vehicles in Use on the Roads. (Random Sample of Vehicles.)*

—	Proportion which did not achieve a maximum deceleration, using the footbrake, of :—		Corresponding braking distance,* in ft., from speeds in m.p.h. of :—			
			20	30	40	50
Private cars	$0{\cdot}50\,g$	31 per cent.	35	80	145	220
	$0{\cdot}40\,g$	12 ,,	45	100	180	280
	$0{\cdot}35\,g$	6 ,,	50	115	210	320
	$0{\cdot}30\,g$	1 ,,	60	135	240	370
Commercial vehicles	$0{\cdot}50\,g$	34 per cent.	Except in the case of light vans, the braking distances for commercial vehicles would be somewhat greater than those given above.			
	$0{\cdot}40\,g$	14 ,,				
	$0{\cdot}35\,g$	8 ,,				
	$0{\cdot}30\,g$	5 ,,				

* These distances do not include any allowance for the reaction time of the driver.

figures quoted in the Highway Code for the braking distances obtainable on good dry level roads represent the shortest distances likely to be achieved by new cars with brakes in good condition. For example, the measured braking distance from 30 m.p.h. for a car with good brakes was found to be about 45 ft., corresponding to an overall deceleration of about $0{\cdot}65g$. The average value of the overall deceleration observed in a random sample of cars in use was about $0{\cdot}43g$, corresponding approximately to a braking distance from 30 m.p.h. of 70 ft., or 50 per cent. more than a car with good brakes.

The best braking performance of commercial vehicles up to about 3 tons unladen weight was about the same as the best cars, although the performance was more affected by the load carried – generally, a shorter braking distance was obtained with the vehicle in the unladen state. Measurements of the braking performance of motor cycles in good condition showed that if the front and rear brakes were applied almost simultaneously so that the rear wheel locked and the front wheel nearly locked, a braking distance could be obtained comparable with that for a car having good brakes. If, however, the front wheel locked on applying the brakes, the rider generally lost control of the machine. If the rear brake only was applied so as to lock the wheel on a good dry surface, the overall deceleration for several machines was found to be about $0{\cdot}35g$.

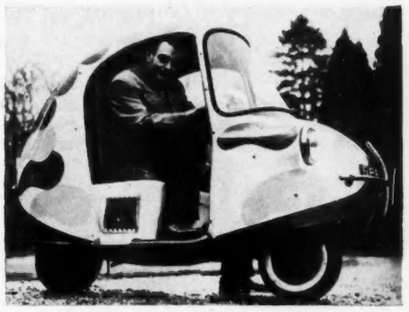

Fig. 12 Motor scooter with saloon body. In the event of an accident, the rider obtains considerable protection from the bodywork.

MINIMUM STANDARD OF BRAKING

Other tests carried out during " Safety Weeks " by firms who make brake-testing apparatus have shown that brake unbalance is very common; 30 per cent. of all cars tested had very little braking on one or more wheels; 12 per cent. had very little braking on one rear wheel, and 6 per cent. had very little on one front wheel. The possible loss of control in an emergency due to unbalanced braking on the front wheels has already been mentioned. The results of these measurements and surveys show that, although the performance of the brakes of new cars is generally good, many vehicles using the roads have a low overall brake performance, and require two or three times the distance to stop stated in the Highway Code; serious brake unbalance is also relatively common. The question of the minimum standard of braking required in order that brakes may be said to be satisfactory is one to which a definite answer based on considerations of safety cannot be given at present. A figure of about $0{\cdot}4g$ for the maximum deceleration (or its equivalent braking distance) is in common use in American States which have vehicle inspection; about 13 per cent. of the vehicles tested in the surveys by the

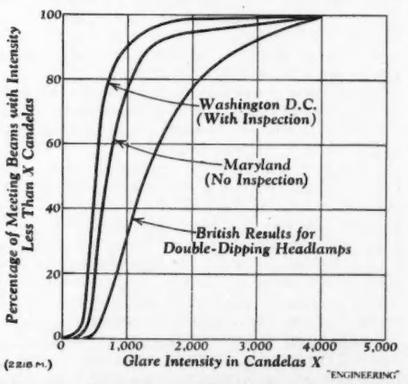

Fig. 13 Comparisons of the glare from dipped headlights in the United States and Britain. The data were obtained from surveys made in 1952-3.

Laboratory would not have reached a standard of 0·4*g*.

FOSTERING GOOD DESIGN AND MAINTENANCE

It seems clear from the discussion in the last two sections of this paper that improvements are possible both in the design and maintenance of vehicles. Improvements in design can come in two ways: (1) by the action of individual manufacturers, and (2) by the enforcement of minimum design standards. The first method is obviously the more desirable one, and in this respect, American manufacturers have set a good example. Some years ago they produced agreed standards for head and rear lamps, with the result that practically all vehicles on the roads of the United States have head and tail lamps conforming to the same standards. Our new cars also conform to these United States standards because they are designed for the export market, but our commercial vehicles do not. Legislation has recently been introduced to enforce good rear lighting, but, as we have seen, many other features of design remain capable of improvement. Of these, it would undoubtedly be possible to deal with headlamps by legislation, but most other features could only be improved as the result of action by the individual vehicle manufacturer. There appear to be two directions in which advances might be made: (1) features which make for safety should be given greater weight when the general styling of the vehicle is being decided, and more care should be taken to ensure that, from the standpoint of safety, each new model is, in every way, an advance on the one it replaces; (2) there should be more concerted action by manufacturers in matters affecting the safety of the vehicle. These remarks apply not only to cars and commercial vehicles, but also to motor cycles.

There is little doubt that improvements in the maintenance of vehicles are even more urgently required than improvements in design, and that the most important problems are those of headlights, rearlights, and brakes. Three methods of achieving better maintenance are commonly considered: (1) by having adequate testing facilities in all garages of any size; (2) by voluntary vehicle inspection at properly appointed garages, and (3) by compulsory inspection. Evidence concerning the effect of such schemes is scanty and comes mainly from the United States, where all three are in use. About one quarter of all American vehicles are subject to compulsory inspection; in one state (Connecticut) a system of voluntary inspection is in use, and, all over the country, excellent facilities for testing lights, brakes and steering are available in garages.

A comparison between States with and without vehicle testing can be made for glare from dipped headlights. During a visit to the United States in 1952 the author made a number of measurements of glare at sites in various States and some of the results are given in Fig. 13. It was found that glare was significantly less in States with inspection than in those not having inspection. Included in Fig. 13 are results for the glare from double-dipping headlights on a British road in 1953. The fact that glare was considerably higher on the British road than at any of the American sites probably indicates the value of the excellent American garage facilities; it might also mean that the effects of vehicle inspection were not confined to the States in which inspection was compulsory.

A disadvantage of the voluntary system in Connecticut is that less than one-quarter of all vehicle owners make use of the facilities provided. One-third of the vehicles which were presented for inspection in 1949 were rejected. This is less than the proportion rejected in most compulsory inspection stations, and probably indicates that those vehicles in greatest need of inspection are not brought in to be tested. There is little doubt therefore that the most effective method of ensuring a satisfactory state of vehicle maintenance is to have compulsory vehicle inspection. The main objections raised are two: first, the cost; and second, doubt whether improved maintenance has any effect on accidents

Figures are available for the cost of vehicle inspection in the United States of America. In the District of Columbia, for example, in 1950–51, the operating costs amounted to 1·2 dollars per vehicle for one inspection a year; in New Jersey, the cost for two inspections per annum in 1949–50 was 88 cents per car; and it has been estimated that a nation-wide inspection programme for two annual inspections in State-owned premises would have cost about 1·5 dollars per vehicle in 1951. Assuming that costs in Britain would be similar, this is equivalent to 10*s*. per car or 2¼ million pounds per annum for 5,000,000 vehicles.

As regards the effect of vehicle inspection on accidents, it is not at all easy to be sure what the figures mean. In 1950, the following comparisons could be made: the National average number of deaths per 100 million miles was 7·5; for those States having inspection, the figure was 6·4; and for those without inspection the figure was 8·0. The most usual comparison to show the value of inspection is the record of New Jersey, which has a very efficient State-operated scheme. Table X gives the figures.

TABLE X.—*Fatal Accidents per 100 Million Miles in the United States*

Year	National average	New Jersey
1946	9·8	5·7
1947	8·8	4·8
1948	8·1	4·2
1949	7·4	4·1
1950	7·5	4·2

Against these figures it is argued that they represent the effects of all kinds of measures besides vehicle inspection, and that they are therefore quite inconclusive. If, however, we accept the accident figures then we may make a comparison as follows. The cost of vehicle inspection in America is about 1 dollar and 50 cents per car per annum, say 10*s*. Road accidents in Great Britain cost about £100,000,000 per annum or about £20 per car. The cost of vehicle testing would therefore be about 2½ per cent. of the cost of accidents. If the American figures for 1950 are accepted, vehicle testing and associated safety measures reduced accidents by 1·6 in 8·0 or 20 per cent., and it would therefore be economically justifiable. Indeed if the improvement were eight times smaller, testing would be justifiable.

It must be remembered however, that a far greater proportion of accidents in the United States of America involve vehicles only than in Britain and that when American figures on accident reductions following vehicle inspection are applied to this country, it is assumed that inspection would be as effective in reducing pedestrian, motor cycle, and cycle accidents as it appears to be in reducing those involving vehicles only.

Estimates of the importance of vehicle defects in accidents provide another indication of the possible scale of the improvement due to inspection. According to Ministry of Transport accident reports, vehicle defects are reported in about 2·5 per cent. and dazzle in 1 per cent. of all accidents; it is generally agreed, however, that this is an underestimate, since policemen are not expert engineers. An analysis by the Army Operational Research Group[4] of accidents to Service vehicles for two months of 1946, showed mechanical defects in 5·6 per cent. of all accidents and dazzle in 2·2 per cent. Even these figures are likely to be underestimated, since Service vehicles are probably maintained in better condition than civilian vehicles. At the least, therefore, there is a likelihood, by means of vehicle inspection, of reducing the influence of a factor which appears in perhaps one-tenth of of all accidents.

Acknowledgments.—This paper was prepared at the Road Research Laboratory of the Department of Scientific and Industrial Research, and is published by permission of the Director of Road Research.

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Correspondence on this British Association paper will be considered for publication in "Engineering."

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LAUNCHES AND TRIAL TRIPS

M.S. "ARNA."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for D/S A/S Sverre, Bergen (Managers: S. M. Kuhnle, Bergen, Norway). Main dimensions: 438 ft. between perpendiculars by 59 ft. 9 in. by 37 ft. 7 in. to shelter deck; deadweight capacity, about 9,730 tons on a mean summer draught of 25 ft. 9½ in. Burmeister & Wain-Harland & Wolff eight-cylinder single-acting four-stroke oil engine, developing 4,400 b.h.p. at 112 r.p.m. in service, installed by John G. Kincaid & Co., Ltd., Greenock. Service speed, 13¼ knots. Trial trip, August 21.

M.S. "STEPHEN BROWN."—Single-screw collier, built by Hall, Russell & Co., Ltd., Aberdeen, for J. and A. Brown and Abermain Seaham Collieries, Ltd., Sydney, New South Wales. Main dimensions: 240 ft. between perpendiculars by 40 ft. by 16 ft. 9 in.; deadweight capacity, 1,800 tons. Eight-cylinder single-acting two-stroke marine Diesel engine developing 1,230 b.h.p. at 240 r.p.m. in service, constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Launch, August 24.

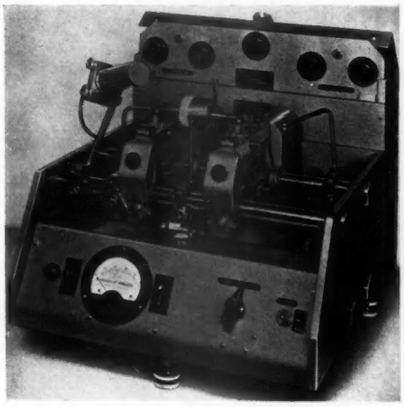
M.S. "GUNNAR KNUDSEN."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for A/S Borgestad, Borgestad, Norway. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in; deadweight capacity, about 17,420 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Loaded speed on trial, about 14½ knots. Delivered, August 25.

M.S. "CYGNUS."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Sociedad Transoceanica Canopus S.A., Panama. Main dimensions: 525 ft. 1 in. overall by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, 16,260 tons on a draught of 29 ft. 1 in. N.E.M.-Doxford five-cylinder single-acting two-stroke oil engine developing 5,500 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Trial trip, August 25.

M.S. "ORMESBY QUEEN."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for Talisman Trawlers, Ltd., Lowestoft. Second of a series of four similar vessels for these owners. Main dimensions: 113 ft. 6 in. overall by 22 ft. by 10 ft. 9 in. Six-cylinder Diesel engine developing 440 b.h.p. at 300 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester, 11. Launch, August 26.

M.S. "INNESMOOR."—Single-screw cargo vessel, built and engined by Hawthorn Leslie (Shipbuilders), Ltd., Hebburn-on-Tyne, County Durham, for the Moor Line, Ltd. (Managers: Walter Runciman & Co., Ltd.), Newcastle-upon-Tyne. Main dimensions: 423 ft. between perpendiculars by 58 ft. by 29 ft. to upper deck; deadweight capacity, 9,540 tons on a draught of about 25 ft. 8¾ in.; gross tonnage, 5,580. Hawthorn-Doxford four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 108 r.p.m. in service. Speed, about 13 knots. Launch, August 30.

S.S. "DISCOVERER."—Single-screw vessel for carrying bauxite ore, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Pan-Ore Steamship Co., Inc. (associates of the Alcoa Steamship Co., Inc.), New York. Second of two vessels built for these owners. Main dimensions: 425 ft. between perpendiculars by 60 ft. by 29 ft. 6 in.; deadweight capacity, about 8,000 tons on a draught of 20 ft. 6 in. Double-reduction geared steam turbines developing 3,300 s.h.p. at 112 r.p.m., constructed by David Rowan & Co., Ltd., Glasgow. Steam generated by two Babcock and Wilcox water-tube boilers. Service speed, 12½ knots. Launch, August 30.



Stroboscopic illumination gives the points at which balance correction must be applied. The accuracy with a 30-lb. rotor is within 0·01 oz.-in.

BALANCING MACHINE

Electronic Indicator for Dynamic Corrections

A range of machines for dynamic balancing, designed primarily for electric-motor rotors, has been introduced by E.M.I. Engineering Development Limited, Wells, Somersetshire. Three types were exhibited at the recent Radio Show at Earl's Court, London, and one model is shown in the illustration above. It can accommodate rotors up to 30 lb. in weight; a smaller bench model will take up to 7 lb. and there is also a pedestal model.

Power to spin the rotor is provided by an electric motor driving (in the model shown) directly by an elastic belt. The rotor rests on two open cradles which are free to move in one plane only. Any unbalance existing in the rotor causes a corresponding movement of the cradles and this movement energises a transducer. There is a separate circuit for each cradle to enable the balancing of each end to be carried out independently. A switch on the front panel selects the circuit to be connected to the meter and a lamp shows which has been chosen.

The signals from the transducers are amplified and used to fire a stroboscopic lamp shining on the rotor. The lamp, which can be seen on the left of the machine, can be adjusted for position. A pointer then indicates the position for the required balance weight and this can be identified on the rotor by a numbered tape bound round it. In the model illustrated, the tuning controls are at the back, and can be folded down into the case when they have been set. The speed range available is from 1,000 to 2,500 r.p.m. The controls allow the machine to be set up so as to take into account any apparent unbalance caused by asymmetry, as, for instance, when the rotor has a fan at one end. It is not necessary when balancing for the rotor to be run at the speed at which it is designed to operate in practice.

When setting up, the circuits are tuned to give the maximum deflection on the meter; this is marked in arbitrary units but can be arranged to give the actual unbalance in any desired units. A multiplier switch is fitted for use when the unbalance is large. The degree of unbalance which can be detected by these machines is very small – for the 30-lb. rotor it is claimed that an error of about 0·01 oz.-in. can be observed and with smaller rotors this becomes proportionately less. In spite of this sensitivity, the machines are suitable for ordinary factory use.

In all models the cradles for the rotor can be adjusted for different lengths of spindle; the larger machine will take work up to 14 in. between bearings and 11 in. in diameter. An end stop is fitted to prevent the work moving axially. A spirit level is fitted for initial setting up, and screws provided for adjustment. In the model illustrated, the elastic driving band can be lifted clear of the rotor by the fingers and looped over two supports while the work is removed. In the pedestal model a fabric belt is used and it has a mechanical device, operated either by a hand lever or compressed air, for lifting the belt clear. This action also stops the motor. The weight of the larger bench model is about 80 lb., and the cradles can be clamped for transport.

* * *

HIGH-POWER STROBOSCOPE

Portable Instrument with Three Methods of Operation

An industrial stroboscope with a high power output is now being made by E.M.I. Engineering Development, Limited, Wells, Somersetshire. This instrument, which is shown in the illustration below, has a peak flash intensity of approximately 100,000 candlepower with a working duration of about 15 micro-seconds per flash. Power is obtained from the ordinary mains supply.

The trigger circuit for the lamp is coupled to a moving-coil meter arranged to read in either revolutions per minute or flashes per second. The accuracy of the meter is 1 per cent. of full scale deflection with a 6-in. scale. The range is up to 100 flashes per second or 6,000 r.p.m. Higher speeds can be measured by reading multiples. There are three methods of operating the lamp: either by mechanical contacts, an electrical pulse, or by an internal oscillator circuit. The first is particularly useful where the lamp has to follow a mechanism which may vary in speed; the second requires a 5-volt sine wave input or a 1-volt positive pulse and can be used in synchronism with many electro-mechanical devices; and the third gives a range from 3 to 100 flashes per second without the need for any external control. In addition, it is possible to synchronise the internal oscillator to any multiple or sub-multiple of the mains frequency and so provide an immediate check of the calibration.

To facilitate the inspection of parts that are awkwardly placed, the lamp can be withdrawn from the body of the unit and used as a torch on a 6-ft. long lead. It is a grid-triggered gas-filled lamp giving a blue-white light. The whole instrument measures 14 in. by 9 in. by 9 in. and weighs 31 lb.

The meter on the top of this stroboscope reads in flashes per second or directly in r.p.m. up to 6,000 r.p.m. The lamp can be withdrawn and used as a stroboscopic torch.

* * *

22-KV SUBMARINE POWER CABLE

Laying Successfully Completed in the Outer Hebrides

The Diesel power station which is now being constructed by the North of Scotland Hydro-Electric Board at Daliburgh, in South Uist, to provide an electricity supply in the Outer Hebrides, will serve the Isle of Eriskay through a submarine cable.

This cable, which has already been laid, was manufactured by W. T. Henley's Telegraph Works Company, Limited, 95 Aldwych, London, W.C.2, and is of the 22-kV screened three-core paper-insulated lead-sheathed and steel-wired armoured type. It was made in a continuous length of 2,900 yards; some deviation from a straight line route was necessary owing to the presence of rock.

Laying was carried out from the S.S. Invercloy, which was equipped with paying-out and braking gear and, being flat-bottomed, could be easily beached for landing the shore ends. The cable was delivered to the docks by road on a drum 12 ft. 4 in. in diameter over the flanges and 7 ft. 11 in. wide; the gross weight when loaded was 38½ tons. It was then coiled into the hold of the Invercloy.

Before laying operations began from Eriskay, soundings were taken over the route at low tide, and rocks which were not visible at high tide were marked by buoys. The end was then landed and run to the overhead line terminal pole, after which paying-out took place at a speed of about 2 knots. The operation proceeded quite smoothly over the route; it was completed in about one hour and was timed so that the Invercloy arrived at South Uist at high water. Here she was beached until low water, when the cable bight was taken ashore and laid up to the terminal pole position.

* * *

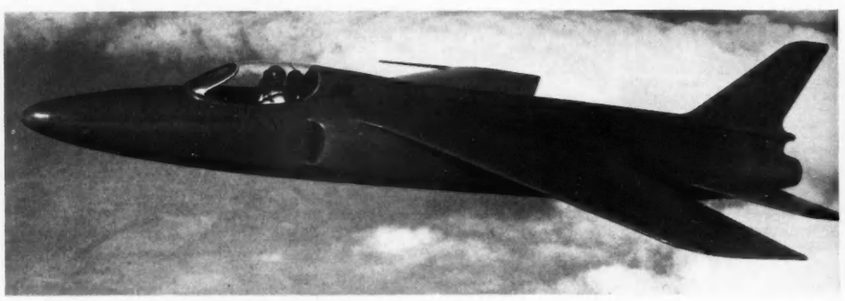
THE "SAXONIA"

Maiden Voyage of Cunard Liner

On Thursday, September 2, the Saxonia, the first of three 22,000-ton liners to be built by John Brown and Company, Limited, for the Cunard Steam-Ship Company's Canadian service, set out on her maiden voyage from Liverpool to Quebec and Montreal. The Saxonia, which has been described in ENGINEERING (page 262, February 26), has accommodation for 125 first-class and 800 tourist-class passengers and about 300,000 cub. ft. of cargo. Two features of special interest, both new to Cunard practice, are the domed-top funnel which discharges smoke clear of the open decks, and Denny-Brown stabilisers.

At a luncheon given on board the Saxonia on Monday, August 30, Mr. J. L. Whitehead, General Passenger Manager of the Cunard Company, spoke of the increase in transatlantic travel which would follow the removal of dollar currency restrictions. Mr. George E. Champion, publicity manager, in proposing the toast to "The Guests," referred to the importance to Canada of immigration and the part played in it by ships of the Cunard Line.

Fig. 6 The Vickers-Armstrongs Supermarine 525, a twin-jet carrier-borne fighter under development for the Royal Navy.



Figs. 7 and 8 The Folland Midge, the prototype of a private-venture lightweight fighter (the Gnat) in flight and, fully assembled, being transported by road.

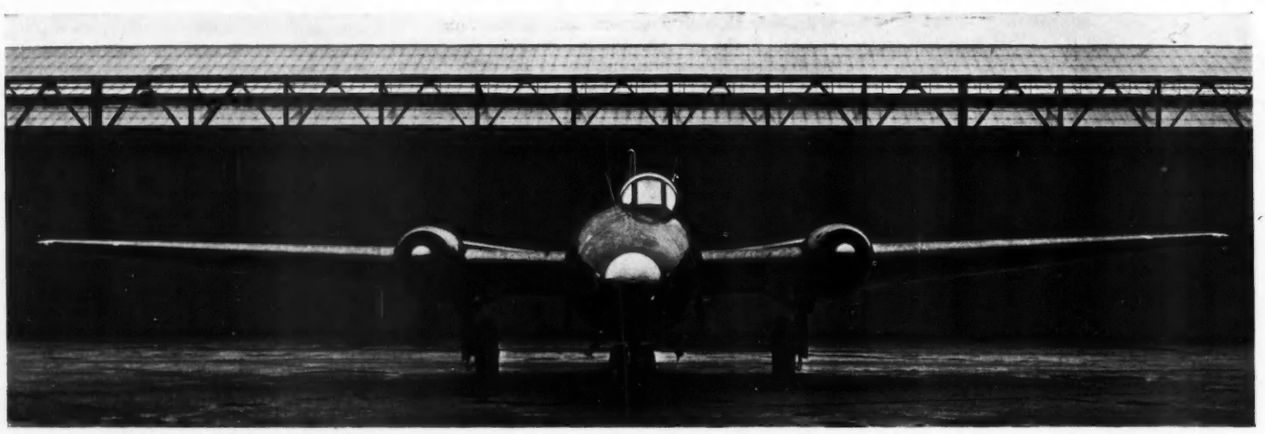


Fig. 9 The Canberra "B" Mark 8 low-level night-intruder aeroplane, with re-designed canopy to improve the pilot's view.

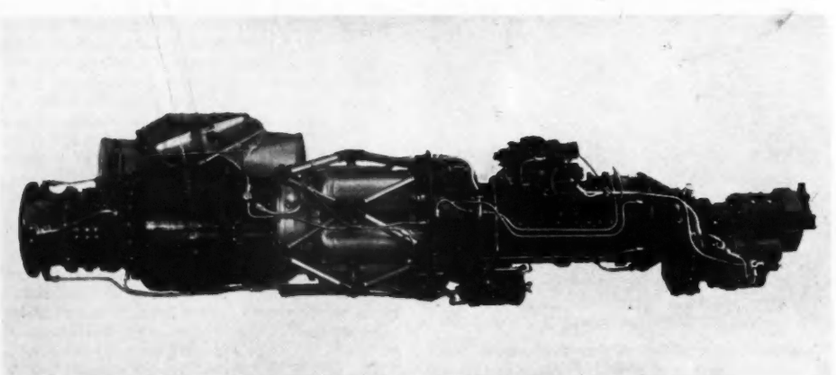


Fig. 10 The Napier Oryx turbo-gas generator for helicopter blade-tip drives.

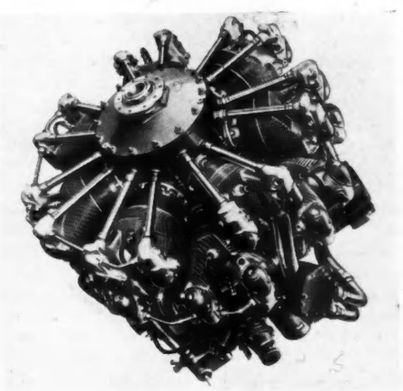


Fig. 11 The Alvis Leonides Major helicopter engine.

AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH

2—FIGHTERS, GROUND ATTACK AIRCRAFT, AND ENGINES

Continued from page 295

The Society of British Aircraft Constructors' annual display at Farnborough comes to an end on Sunday, September 12. Last week, we discussed the part played by the Short and Harland SB5 research aircraft in the development of the supersonic English Electric P1 fighter aeroplane; the Hunter Percival Jet Provost trainer and the armed Provost; and the Auster A.O.P. Mark 9 air-observation post. This week we propose to describe some of the new fighter and ground-attack aircraft and the engines which have been seen for the first time.

Before turning to the new machines, however, it is of interest to note that the Hawker Hunter Mark 1 fighter aircraft, now going into service, has secured overseas orders worth £120,000,000 from the NATO air forces. A new variant of the Hunter, the Mark 6, has been seen briefly over Farnborough during the week, flown over from Dunsfold aerodrome. No details have been released on the Hunter Mark 6, but it is believed to have a more powerful Rolls-Royce Avon engine installed. The Vickers-Armstrongs' Swift F Mark 4, also taking part in the display, was the first British swept-back wing fighter to enter service with the Royal Air Force.

Both of these production machines, capable of diving to supersonic speeds, are fitted with Rolls-Royce Avon engines equipped with reheat, and are armed with four 30-mm. Aden guns mounted in the fuselage. The Vickers-Armstrongs company claim that the Swift has a greater internal fuel capacity and longer range than any corresponding contemporary aircraft. It has a pressure-fuelling system, and there is provision for carrying an external drop tank slung beneath the fuselage.

It is also interesting to learn that the Gloster Aircraft Company, Limited, Hucclecote, Gloucestershire, claim to be ahead of schedule in the production of the Javelin delta-wing all-weather fighter, five of which, in formation, form the concluding item in the display. The outer-wing area of the Javelin has been increased slightly to give better aileron control.

ALL-MOVING TAIL ON DH 110 FIGHTER

The DH 110 all-weather fighter aircraft, now being developed by the de Havilland Aircraft Company, Limited, Hatfield, for carrier-borne and land-based use in the Royal Navy, is appearing again at Farnborough, this time with an all-moving tailplane. It is stated to be the first British aircraft to fly with an all-moving tail. The DH 110 is powered by two Rolls-Royce Avon engines, has a span of 51 ft., and a length of 52 ft., and was the first British aircraft to dive through the sound barrier.

SUPERMARINE 525 EXPERIMENTAL NAVAL FIGHTER

The twin-jet swept-wing Supermarine 525 aircraft constructed by Vickers-Armstrongs Limited, Hursley Park, Winchester, which has appeared in public for the first time this week, is stated by its constructers to be the second stage in the development of a twin-jet carrier-borne naval fighter aircraft on order for the Royal Navy. The first stage was the Supermarine 508, a straight-wing aircraft with an unconventional "butterfly" tail unit powered by two Rolls-Royce Avon engines, which made its first appearance at Farnborough two years ago.

The Supermarine 525, which can be seen in Fig. 6, has reverted to conventional fin and tailplane surfaces, both with pronounced sweepback. The tailplane is set above the fuselage on the fin, the rudder being divided into two portions above and below the tailplane.

As in the earlier machine, power is supplied by two Rolls-Royce Avon engines installed side by side in the widened fuselage aft of the pilot, with intakes on each side well forward of the wing root. The main units of the tricycle undercarriage retract inwards into the wing root and the nosewheel folds backwards into the fuselage below the cockpit. It may be observed from the illustration that the aircraft is equipped with an arrester hook.

No performance details of the Supermarine 525 have been released but it is generally believed to be one of the fastest aircraft yet constructed in the United Kingdom.

FOLLAND MIDGE LIGHTWEIGHT FIGHTER

The aircraft which has probably aroused the widest interest is the private-venture Midge, designed and constructed by Folland Aircraft Limited, Hamble. The Midge is the unarmed prototype of the Gnat light-weight fighter aircraft – also a private venture – which is to be powered by the Bristol Orpheus jet engine still under development.

The Orpheus engine, it is stated by the Folland company, will, when fully developed, produce three times the power of the 1,640-lb. thrust Armstrong Siddeley Viper installed in the Midge. Even with the lower thrust, it is claimed that the Midge has a maximum level-flight speed greater than 600 m.p.h., and it is expected that ultimately the Gnat will be capable of supersonic speed in level flight, with an outstanding rate of climb.

As may be judged from Fig. 7, the Midge is one of the most graceful machines to be seen at Farnborough. A good idea of its small span, 20 ft. 8 in., and its transportability may be gathered from Fig. 8, which shows it being transported by road on a "low loader" from the manufacturer's works to the Aircraft and Armament Experimental Establishment, where it carried out its first trials in early August. Its overall length is 28 ft. 9 in. and it is 8 ft. 3 in. high.

The wing of the Midge is swept back 40 deg. and, when static, it has an anhedral of 5 deg. The Viper engine is installed in the rear fuselage and draws its air supply from twin intakes on each side of the fuselage, which is widened to accommodate them. The jet pipe is in the tail, and it may be observed that the swept-back tailplane appears to be set on the fuselage with its hinge line practically on the thrust axis. The tailplane is of the "all-moving" type (although on this first aircraft elevators are also fitted) and is power-operated by a hydraulic pack. The rudder and aileron, of conventional form, are manually operated, but on the Gnat the ailerons will be power-operated and they will be located inboard. An exceptionally high rate of roll over a wide range of speed and altitude is forecast for the Gnat. All the fuel tanks are located within the fuselage, the main tank being between the engine air intakes.

MORE FIGHTERS FOR LESS MANPOWER

The object of the Gnat fighter, for which the Midge is to be a proving vehicle, is simplicity and economy in construction, operation and maintenance without sacrificing fighting qualities and versatility. It has, in fact, been suggested that its light weight and small dimensions – about one-half and one-third respectively of that of a standard fighter – may show to advantage in combat against its heavier contemporaries. All possible complications have, therefore, been eliminated. For instance, the Midge has no landing flaps and no separate dive brakes – the undercarriage legs are designed to perform this function and can be lowered at high air speeds. All units retract backwards into the fuselage and are hydraulically operated. The simple door fairings eliminate the complication of sequence valves in the undercarriage circuit. The nosewheel is castoring and non-steerable.

The pressurised and air-conditioned cockpit is enclosed by a Perspex pressure moulding made by the Folland company. The light-weight fully-automatic ejector seat has also been specially developed, within the Folland organisation, from a Swedish design, and is on view in the static exhibition, as is also a working model of the moving tailplane.

The Folland company claim that five Gnat airframes can be made in the same number of man-hours as those required for one standard fighter airframe, and that 20 fully-equipped Gnats would cost the same amount as six standard fighter aircraft.

CANBERRA "B" MK 8 NIGHT INTRUDER

A new mark of Canberra, the "B" Mark 8 low-level night-intruder aircraft, has been developed by the English Electric Company, Limited, Warton Aerodrome, Lancashire, in which, as illustrated in Fig. 9, the forward part of the fuselage has been completely re-designed, with an asymmetric transparent canopy in which the pilot is seated in a higher position than in earlier marks to provide a better view for carrying out ground attack. The navigator has a good forward and downward view from additional windows in the nose.

A gun pack in the rear half of the bomb bay has four 20-mm. guns with a considerable quantity of ammunition for each gun. The forward half of the bomb bay can accommodate either flares or bombs. Additional armament can also be carried on wing pylons.

NEW TURBINES – THE ORYX AND THE SOAR

It was something of a disappointment that security restrictions prevented the appearance this year of the de Havilland Gyron axial-flow jet engine in the static exhibition. It is stated by the de Havilland Engine Company, Limited, Leavesden, that for the past year the Gyron, which is designed for fighters requiring near-vertical climb to the stratosphere and level supersonic interception, has been giving a thrust greater than that announced for any other jet engine.

Two new gas-turbine engines are on view for the first time – the Napier Oryx turbo-gas generator and the Rolls-Royce Soar light-weight jet engine. The Oryx, designed and constructed by D. Napier and Sons, Limited, Acton, London, W.3, is intended for helicopter-rotor tip-jet propulsion and will, it is believed, be installed in the Hunting Percival helicopter now under

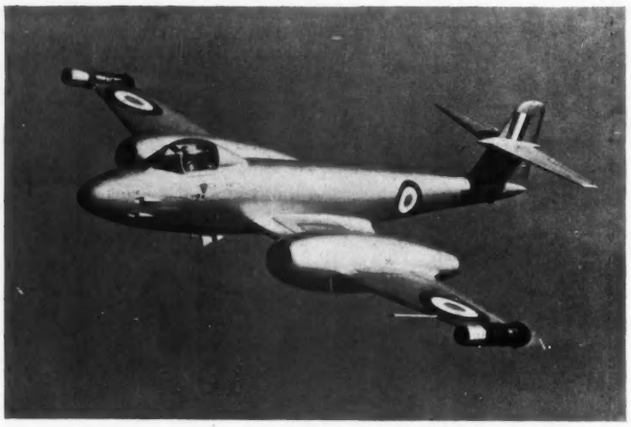


Fig. 12 The Meteor flying test-bed for the Rolls-Royce Soar engines (see Fig. 13), installed at the wing tips.

development. The Oryx, which is illustrated in Fig. 10, is fitted with an axial compressor, and has five combustion chambers. It has a sea-level output of 750 gas horse-power and a corresponding specific fuel consumption of 0·68 lb. per g.h.p. per hour. The Oryx weighs 495 lb., has a maximum diameter of 19·25 in., and an overall length of 76 in.

NEARLY 7 LB. THRUST PER LB. WEIGHT

The Soar axial-flow engine recently announced by Rolls-Royce Limited, Derby, is the outstanding engine exhibit this year. It is illustrated in Fig. 13. The Soar is on view both in the static exhibition and in the flying display, installed in the tips of a Gloster Meteor aircraft, shown in Fig. 12. The normal Derwent engines are not used during the demonstration run. Rated at 1,810 lb. thrust, it has passed a type test at 1,860 lb. thrust and weighs only 267 lb. – i.e., for every pound of engine weight it has developed just under 7 lb. thrust. It is interesting to compare these figures with those quoted for the R.A. 16 civil version of the Avon engine, for which the net dry weight is stated to be 2,710 lb. and the thrust developed is 10,000 lb. – i.e., 3·7 lb. thrust per lb. weight. It is clear that there is some exceptionally interesting development work built into the Soar. The overall length of the engine is 62·75 in. and it is 15·75 in. in diameter.

DROPPABLE ROCKET-MOTOR UNIT

Among other engines on view in the static exhibition are the Armstrong Siddeley Sapphire, now powering the supersonic English Electric P1 fighter as well as the prototype Avro Vulcan bomber and the Hunter Mark 2 fighter aircraft; and the Mamba and Double Mamba propeller turbines developed by the same company. Armstrong Siddeley Motors Limited, Coventry, are also again showing the Snarler rocket motor, now on the "open list." We hope to publish a description of the development of the Snarler in a forthcoming issue. Another liquid-fuel rocket motor, the Super Sprite, developed by the de Havilland Engine Company, Limited, which appeared in last year's static display is exhibited this year as a complete droppable unit in a container equipped with the dropping mechanism, parachute, and landing shock absorber.

Engines shown by the Bristol Aeroplane Company, Limited, Filton, include the Proteus propeller turbine (also flying, with commendable silence, in its Ambassador test bed), the Olympus turbo jet (also flying in a Canberra test bed), and a Centaurus radial piston engine. The Napier company, in addition to the new Soar jet, are showing the Nomad compound engine and the Eland propeller turbine – the latter also taking part in the flying display in a Varsity test bed. Both the Napier engines have been described in detail in ENGINEERING (page 570, vol. 177, April 30, 1954, and page 121, vol. 178, July 23, 1954).

Rolls-Royce Limited are also showing a representative of the growing family of Avon turbo-jets, and a Dart propeller turbine of the type which has played such a large part in the success of British European Airways' Viscount services and in the mounting overseas orders for Viscount air liners. Blackburn and General Aircraft Limited, Brough, are exhibiting, in addition to their Bombardier direct-injection 180-h.p. piston engine, four representatives of the Turbomeca range of light gas turbines that they manufacture under licence – the Palouste 139-lb. per minute turbo-compressor, and Marborne 883-lb. thrust jet engines, and two British-designed developments – the Palas 600 jet engine developing 390 lb. thrust and the 450-h.p. Turma shaft turbine.

LEONIDES MAJOR HELICOPTER ENGINE

Alvis Limited, Coventry, are exhibiting their Leonides 550-h.p. and Leonides Major 870-h.p. engines, the latter being exhibited for the first time in the helicopter version (Fig. 11, on page 346). A brief description of the Leonides Major engine was given on page 187 of our issue of February 6, 1953 (vol. 175). When installed in a helicopter it is not normally fitted with a reduction gear but is equipped with a clutch and cooling fan mounted immediately above the timing-case front-cover plate. In other respects it is identical with the standard Leonides Major. The Alvis Leonides Major, it may be recalled, has been installed in the Westland-built S.55 12-seat helicopter which is on order for the Royal Navy for communications and general duties.

To be continued

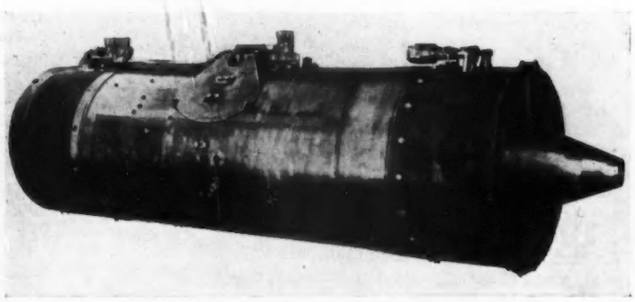


Fig. 13 Rolls-Royce Soar axial-flow jet engine, which develops 1,810 lb. thrust and weighs only 267 lb.

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CONTRACTS

Gas Mains. A contract worth about half-a-million pounds has been awarded to COSTAIN-JOHN BROWN, LTD., 73 South Audley-street, London, W.1, by the Welsh Gas Board for the laying of gas pipelines in North and South Wales. The contract is scheduled for completion in 1956.

Hawker Hunter Aircraft. It has been announced by the HAWKER SIDDELEY GROUP LTD., 18 St. James's-square, London, S.W.1, that export orders for their Hawker Hunter, a swept-wing supersonic interceptor fighter, have now reached a total value of £121 millions; the largest single order within this figure is valued at 182 million dols. placed by the United States Government on behalf of NATO. The size of orders placed by the British Government on behalf of the Royal Air Force have not been revealed for security reasons.

Television Equipment. A repeat order has been placed by Radio Audiziore Italiana through Marconi Italiana with MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, for a substantial quantity of television equipment. The new contract orders complete equipment for two further television outside-broadcast units, the equipping of another two-camera studio and a large quantity of monitoring apparatus. It calls for the provision of eight camera channels, three sound and three vision mixers, twenty picture monitors, ten picture and waveform monitors, six line stroke waveform monitors, five micro-wave links and ancillary equipment.

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STREET LIGHTING IN BRITAIN

Eastbourne Conference

The annual conference of the Association of Public Lighting Engineers, on "Street Lighting Apparatus and Equipment," will open at Eastbourne next Tuesday, September 14, and will continue until the morning of Friday, September 17.

The proceedings will commence with the annual general meeting and the induction of the new President, Mr. L. A. Doxey, street lighting engineer, Leeds, on the morning of September 14. In the afternoon, Mr. Doxey will deliver his presidential address and there will be a paper on "Street Lighting and Road Safety," by Mr. W. Robinson, of the British Electrical Development Association.

Other technical sessions will be held at the Winter Garden, Devonshire Park, on the morning and afternoon of September 16 and the morning of September 17, when papers on some unusual uses of fluorescent lamps in street lighting, the control of street lighting, research on accident statistics and road-surface characteristics in relation to street lighting, and "Details of a Wise Compromise in Street Lighting" will be read. There will be a reception by the Mayor of Eastbourne at the Winter Garden on the evening of September 14, a tour of inspection of lighting installations on the evening of September 15, and a reception by the President at the Winter Garden on the evening of September 16.

During the conference, there will be an exhibition of street lighting apparatus and equipment and outdoor displays of lamp columns and mobile equipment.

Mr. Eric Evans is the secretary of the Association, the headquarters of which are at 22 Surrey-street, London, W.C.2.

SHIELDED-ARC WELDING PLANT WITH WATER-COOLED GUN

HIGH-SPEED WELDING OF DIFFICULT MATERIALS

The Quasi-Arc Company, Limited, Bilston, Staffordshire, have introduced a new shielded-arc welding plant, the Sigma, which is of American origin, and which they are manufacturing under an exclusive licence for Great Britain and the Commonwealth countries, with the exception of Canada. The Sigma plant operates on the well-known principle of shielding the welding arc with argon gas, and incorporates a wire-feed mechanism to supply electrode wire automatically from a spool as it is consumed. The electrode wire holder is in the form of a lightweight gun which is water cooled.

The plant is particularly suitable for metals having poor welding characteristics, such as aluminium and its alloys, and stainless and heat-resisting steels, but it is applicable to most metals which are commercially weldable. The speed of operation is high; butt welding of $\frac{1}{16}$ in. thick aluminium plates, for example, can be carried out at a speed of up to 36 in. per minute. As the shielded-arc process does not require a flux, the electrode is simply an uncoated wire of the same material as that being welded, and the possibility of corrosion due to trapped slag is eliminated. There is virtually no spatter from the welds, and as there is no stub loss, as with normal manual welding, 95 to 100 per cent. of the welding wire is deposited. Loss of alloying elements from the electrode as it crosses the arc is negligible, and the weld is of the same composition as the parent metals.

The plant consists of a cabinet containing the welding-current rectifier and contactor, a wire feed mechanism and control unit, and a welding gun. A fabricated sheet-steel cabinet, with four wheels, two of which are castors, houses the rectifier. A push-handle is fitted for easy portability, and there are lifting eyes to facilitate slinging from a crane. The rectifier is of the Quasi-Arc metal type, taking current from a 360/440-volt 3-phase supply, and having a direct-current output of 55 volts, with a maximum capacity of 425 amperes. On a 75 per cent. duty basis (that is, three minutes on and one minute off), the rectifier will deliver 400 amperes.

In the Sigma shielded-arc welding plant, the electrode is fed automatically at a constant speed; over 95 per cent. of the wire is deposited.

The design gives a flat volt-ampere output characteristic, which emphasises the self-adjusting properties of the welding arc. The rectifier is provided with a stepless remote control, which enables the output to be varied between 85 and 425 amperes, the actual current-control box being equipped with a length of cable, so that it can be taken by the operator to his working position. Alternatively, when convenient, the current-control box can be attached to a bracket on the side of the cabinet, where provision is also made for mounting an argon cylinder.

The welding wire is fed from a spool through a pair of traction rollers, and thence through a light flexible conduit to the welding gun. The wire spool, driving motor, electronic governor and control gear form a separate unit, which is normally mounted on top of the rectifier cabinet, but can, when necessary, be detached and located elsewhere. A remote-control box, which can be taken to the operator's working position, is provided to enable the wire feed rate to be selected and varied as required. Once the feed rate has been set, the electronic governor in the control unit holds it constant, irrespective of variations in load conditions.

The welding gun is of lightweight construction, and is water cooled by means of a hose connection to a town water main or any other convenient source of supply. The water which cools the gun is also used for cooling the cable carrying the welding current from the rectifier to the gun. As a result, it has been possible to use a 50-ampere cable to carry the full welding current of 400 amperes, and the cable is therefore very light and flexible. This, coupled with the light weight of the gun, and the fact that the wire-feed and shielding-gas hose are also small and of maximum flexibility, facilitates welding in the vertical and overhead positions with a minimum of operator fatigue. The gun, together with the wire-feed and welding-current control boxes, can be taken to inaccessible positions, such as the interior of a pressure vessel, or a fabricated structure, and the correct welding conditions can be maintained at all times by the operator, while the control unit remains at a distance. The rectifier can, of course, be in any position, and at any distance from the work. In one installation, for the fabrication of light-alloy railway rolling stock, the control unit has been suspended from an overhead runway, in order to give the operator freedom to move about.

The operation of the plant is simple. Welding current and wire-feed rate having been set, it is only necessary to bring the gun to the welding position, and press the trigger. This operates, through relays, the welding current contactor, and the welding wire is energised through a copper guide tube in the gun. Simultaneously, by means of similar relays, the valves controlling the shielding gas and cooling water are opened, and the gun is ready for use. Wire feed begins automatically when the arc is struck. On completion of the weld, the trigger is pressed once more, which cuts off all the services to the gun, and leaves the correct length of welding wire projecting, ready for striking a fresh arc.

Safety devices are incorporated in the control unit to ensure that welding cannot proceed unless the supply of cooling water is adequate, and to switch off the plant should anything interfere with the wire feed. This latter control operates automatically when the end of a coil of wire is reached, and in any other circumstances which would prevent the continuous feed from working normally, and prevents the striking of an arc between the work and the copper guide tube in the gun. When the coil of wire is exhausted, or it is necessary to fit a fresh coil of a different metal, the gun can be dismantled quickly by removing one knurled nut.

Both the welding gun and the cable from the rectifier are water-cooled, the cable being combined with the water hose.

* * *

"SUPERCHARGED" PROPELLER TURBINE

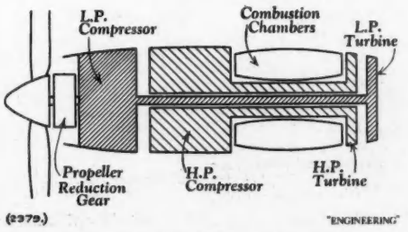
Good Performance at High Altitudes

Preliminary details have been released by the Bristol Aeroplane Company, Limited, Filton, of a new type of aircraft propeller turbine, the 4,000-h.p. BE25, which they describe as a "supercharged turboprop." Initiated as a private venture and designed specifically for transport aircraft, the BE25 has now been given a Ministry of Supply contract. With the new form of power unit, it is stated, constant power can be maintained from sea level up to cruising altitude, whereas the normal engine loses power as the air density decreases with altitude. The fuel consumption is so low that, it is claimed, the BE25 is competitive with a Diesel engine.

The principle of the supercharged turboprop – which combines the best features of the free-turbine propeller drive, as in the Bristol Proteus propeller turbine, and the two-spool layout, as in the Bristol Olympus – is illustrated below.

The high-pressure compressor, combustion chambers and high-pressure turbine can be considered as a gas generator, providing a stream of high-velocity high-temperature gas which drives the low-pressure turbine. The latter is connected by a shaft to the low-pressure compressor, which supercharges the high-pressure compressor and also drives the reduction gear and propeller.

There is no mechanical coupling between the high-pressure and low-pressure compressor-turbine systems. This makes it possible to operate the gas-generator section of the engine at its maximum efficiency while at the same time the propeller also can be operated efficiently.



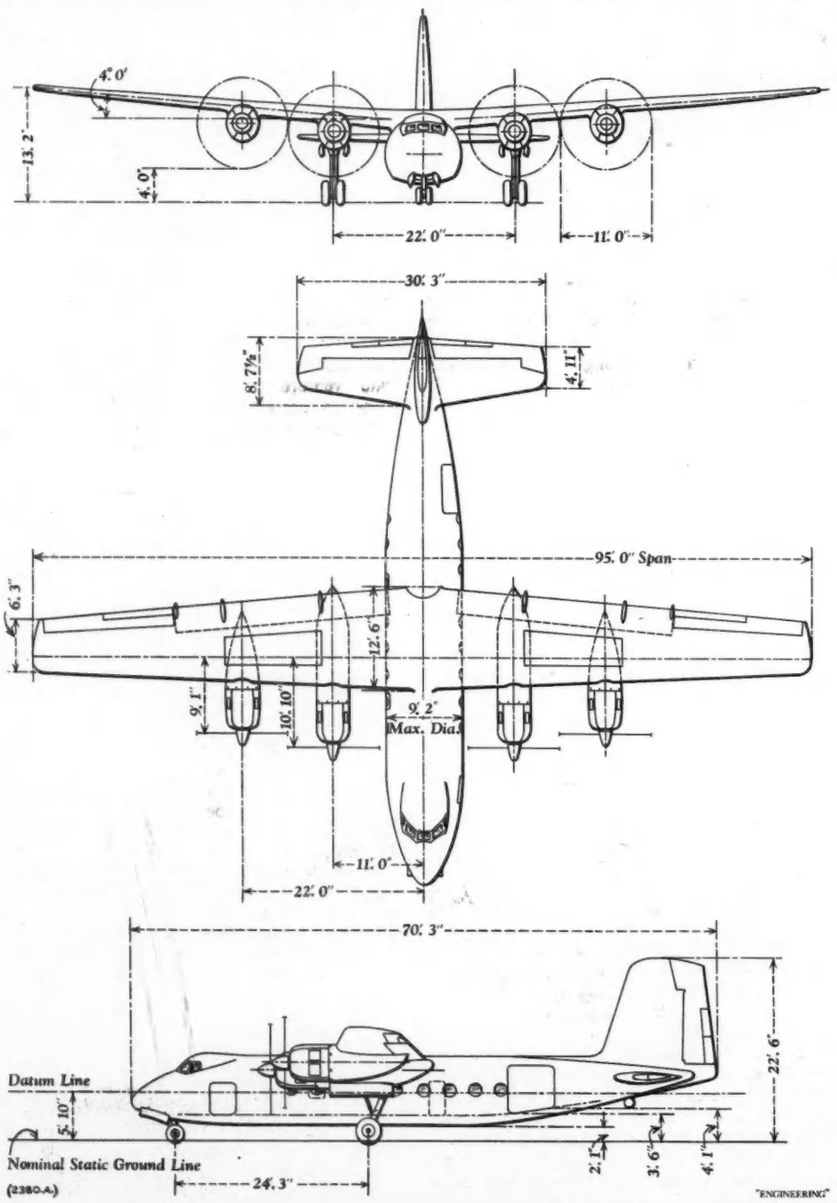
Diagrammatic layout of the "supercharged" propeller turbine.

AIR-LINER FOR SHORT AND MEDIUM RANGES

TWO HANDLEY PAGE PROTOTYPES UNDER CONSTRUCTION

A year ago Handley Page, Limited, Cricklewood, London, N.W.2, announced that they had a projected design for a short and medium-range air-liner, the H.P.R.3, intended as a "D.C.3 replacement," for heavy duty under varied conditions of climate and operating facilities. Two prototypes of this machine, which is to be known as the Herald, are now under construction. The first is expected to fly next year. A production line is being set up, and it is hoped to be able to commence deliveries in 1957.

An extensive survey of commercial air-line requirements throughout the world showed that the primary requirements for a D.C.3 replacement were a good take-off performance (in the tropics and at high altitude as well as under standard atmospheric conditions); ease of loading and unloading; the use of four engines as a greater safety measure, and – since there is at present only a very small background of operating and servicing experience of propeller turbines – a preference for piston engines; and a flexible cabin layout so that, by rapid removal of seats and partitions, an air-liner can quickly be converted to a freight carrier. The Herald has therefore been designed to these specifications.



General arrangement of the Herald civil-transport aircraft, which provides accommodation for 36/44 passengers or more than 10,000 lb. of freight or a combined load. It will operate over stage distances up to 1,800 miles.

Designed to carry 36 first-class or 44 tourist passengers, or about 10,000 lb. of freight, or as a mixed passenger/freight transport aircraft, the Herald is a high-wing monoplane with a twin-wheel hydraulically-operated retractable tricycle undercarriage, powered by four Alvis Leonides Major engines each developing 870 h.p. for take-off. The cabin is air conditioned and pressurised to a maximum differential of 3·35 lb. per square inch, equivalent to a cabin altitude of 6,500 ft. when the aircraft is flying at 15,000 ft. Provision is made for de-icing the wings and tail surfaces either thermally or by inflatable "boots," and anti-icing will be provided for the windscreen and propeller blades.

The dimensions of the Herald are as follows: wing area, 882 sq. ft.; span, 95 ft.; overall length, 70 ft. 3 in.; overall height, 22 ft. 6 in. The cabin, 42 ft. long, has a volume of 2,070 cub. ft. The maximum all-up weight, for take-off and landing is 34,000 lb. and the maximum possible payload is 10,705 lb. The fuel capacity normally provided is 700 Imperial gallons, in four bag tanks (two each side) in the centre-section wing. There is, however, space for an additional 300 gallons.

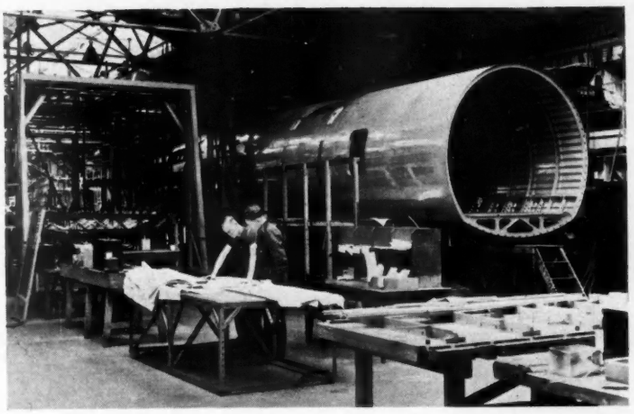
At an all-up weight of 34,000 lb., it is predicted that the Herald, which is provided with hydraulically-actuated Fowler flaps, will take off and land over a 50-ft. obstacle within a distance of less than ½ mile. At 50 per cent. of maximum continuous power, at an estimated average speed of 194 m.p.h., at 10,000 ft., the still-air range and payload performance are calculated as follows: range when carrying maximum payload (10,705 lb.), about 350 miles; with 700 gallons of fuel, and corresponding payload, 6,930 lb., the maximum range is just over 1,400 miles; over a range of 500 miles a payload of more than 10,000 lb. can be carried, and over 1,000 miles the possible payload is nearly 8,400 lb. When equipped with tanks for 1,000 gallons of fuel, the maximum still-air range with full tanks is over 2,000 miles and the corresponding payload about 4,650 lb. Over a range of 1,500 miles, a payload of 6,500 lb. can be carried. These ranges, it should be noted, do not take account of necessary fuel reserves, and the maximum practical stage distance, in zero wind, is about 1,800 miles.

FUSELAGE CONSTRUCTION

The fuselage of one of the prototype Heralds under construction can be seen in the illustration opposite. With the exception that the longitudinal stringers are welded to the fuselage skin, the light-alloy fuselage is of conventional design. In the centre-section wing, which extends across the fuselage and houses the engines and fuel tanks, a multiple-box-spar construction is employed with three shear webs and "metal-sandwich" skins formed by two light-alloy sheets separated by spanwise corrugated sheeting, the latter being spot-welded to the inner and outer skins; in the outer wings, a normal two-span box construction with pierced ribs and spanwise stringers is used. The tail-plane and fin are also of multi-span construction, but in this case a single chordwise-fluted skin forms the compression and lower members of the box spar.

For operating the flaps, undercarriage, nose-wheel steering, and wheel brakes, a 3,000-lb. per square inch hydraulic system will be provided, with an independent pneumatic system for emergency operation. The electrical services will be supplied by two 6-kW direct-current generators regulated at 28·5 volts to give a normal rating of 200 amperes. For storage, one 24-volt 25-ampere hour accumulator and an emergency accumulator will be provided.

Normally a crew of two will be carried, cap-



Herald prototype fuselage under construction. The first machine is expected to fly next year.

tain and first officer/navigator, but it will be possible also to carry a radio operator if necessary. Duplicated flying controls and flight instruments are provided, the other controls and instruments being located on a central pedestal, roof panels and side panels. Radio and navigational aids will be installed in protected roof-racks on the starboard side of the forward freight hold, on the flight deck behind the pilot's seats. Both engine and flying controls are to be manually operated through push-pull rods, and all the control surfaces will be fitted with mechanically-operated trimming tabs. The tail-surface controls are carried below the cabin floor, and all control runs will be easily accessible through large hinged panels.

COAL-BURNING GAS-TURBINE LOCOMOTIVE

THE NORTH BRITISH LOCOMOTIVE CO. DESIGN

Further information on the experimental coal-burning gas-turbine locomotive which is being designed and built by the North British Locomotive Company, Limited, Glasgow, is now available. The company are working in conjunction with C. A. Parsons and Company, Limited, Newcastle-on-Tyne, and are building the locomotive to the order of the Ministry of Fuel and Power. The British Transport Commission are also interested in the locomotive.

The problem of turbine-blade erosion is being solved by using hot air as the working fluid, as described in ENGINEERING for January 8, 1954, page 39. The cycle is as follows: air from the atmosphere, at a maximum flow of 34·04 lb. per second, is compressed and then passed over the tubes of an exhaust heat exchanger, where it is heated to nearly 1,300 deg. F.; it then drives a turbine which provides power for the compressor, and then a turbine which is geared to the locomotive wheels. The air, still warm, is fed to a combustion chamber in which pulverised coal is burnt. The resulting hot gases are well mixed to prevent hot spots, and passed through the tubes of the heat exchanger.

It is now stated that the maximum turbine temperature will be 1,292 deg. F. and the maximum heater temperature 1,528 deg. F. The maximum efficiency will be 19·1 per cent., and the power available at the turbine shaft will be 1,750 h.p. The wheel arrangement is A1A-A1A, i.e., two six-wheeled bogies (with 3 ft. 9 in. wheels), each having four driven wheels. With a total weight of 120 tons the adhesive weight will be 80 tons and the axle load 20 tons.

TWO-SPEED GEARBOX

The power turbine will be geared directly to the driving wheels, and the main reduction gearbox will provide for reverse and two forward speed ranges – one for passenger traffic and the other for freight. The maximum speeds in these two ranges will be 72 m.p.h. and 50 m.p.h., and the corresponding starting tractive efforts will be 30,000 lb. and 45,000 lb. The drive is through cardan shafts to allow for movement of the bogies on curves and for the flexing of the springs. Differentials in the main gearbox and in transfer boxes on the bogies divide the load between four axle-mounted bevel and open final-drive gearboxes.

The first, experimental, locomotive will be a single unit with a driver's cab at one end. The coal, previously pulverised in a stationary plant, will be carried in a bunker on the locomotive. With a fuel capacity of 6 tons the estimated operating range is 500 miles (this may be compared with the 8 or 9 tons capacity of existing express passenger locomotives working the 400-mile run from London to Glasgow and Edinburgh). The driver will have controls for starting the burner on oil and changing over to coal. Starting and warming up the heater is stated to take about 25 minutes (compared with several hours for a reciprocating locomotive – the exact time depending on the temperature of the boiler).

Driver's controls will be the turbine control, the heater temperature control and the usual handles for a Westinghouse vacuum-controlled straight air brake. The turbine control is reported to provide immediate response but reduces the efficiency at part loads. Reducing power on the heater control permits considerable economies, but the driver will have to anticipate the next demand for power by five to ten minutes to allow time for the heater to warm up, much as the fireman of a steam locomotive must ensure that there is a full head of steam for a heavy grade.

The experiment, it is stated, is still in its early stages and some time will elapse before the builders know whether the two new principles in gas-turbine locomotive design – the exhaust-heater coal-burning cycle and direct mechanical drive – fulfil expectations. Later developments are expected to take differing forms to suit the requirements of other railways. The basic features have been designed with these future possibilities in mind but the prototype is arranged to be suitable for British Railways, on whose tracks it will first be tested.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Industrial Space Heating," by C. S. Whitby. South-West London Branch. Guild House, 32 Worple-road, Wimbledon, S.W.19. Wed., Sept. 15, 8.15 p.m.

BOLTON
"Transformer and Switch Oil," by G. Stott. Bolton Branch. Balmoral Hotel, Bradshawgate, Bolton. Mon., Sept. 13, 7.30 p.m.

CHATHAM
"Cathode-Ray Picture Tubes," by H. J. Beach. Kent Branch. Sun Hotel, Chatham. Thurs., Sept. 16, 8 p.m.

MANCHESTER
"Applications and Characteristics of Induction Motors," by F. T. Bartho. Manchester Branch. Engineers' Club, Manchester. Wed., Sept. 15, 7.30 p.m.

NOTTINGHAM
Chairman's Address. Nottingham Branch. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Wed., Sept. 15, 7.30 p.m.

WATFORD
"Power Factor Correction," by F. T. Bartho. Watford Branch. Clarendon Hotel, Station-road, Watford, Hertfordshire. Thurs., Sept. 16, 8 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Materials Handling in Saw Mills and Its Problems," by H. B. Marson. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Sept. 24, 7.30 p.m.

BLACKBURN
Discussion on "Management." Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Sept. 16, 7.30 p.m.

BRISTOL
"Planning and Reconstruction in Bristol," by R. W. Jefford. Western Branch. Grand Hotel, Bristol. Wed., Sept. 15, 7.15 p.m.

DUNDEE
"Manufacture of Ball and Roller Bearings," with film, by W. N. Mills. Dundee Branch. Mathers Hotel, Dundee. Mon., Sept. 13, 7.30 p.m.

GLASGOW
"Compressed Air in Industry," by H. Burnett. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow. Wed., Sept. 15, 7 p.m.

ROCHESTER
"Causes and Prevention of Steam-Plant Scale," by W. F. Gerrard. Kent Branch. Bull Hotel, Rochester. Wed., Sept. 15, 7 p.m.

Institute of Marine Engineers

LONDON
Presidential Address, by H. A. J. Silley. Tues., Sept. 28, 5.30 p.m.

GLASGOW
"The Condensing Gas Turbine," by J. F. Field. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Sept. 22, 7.30 p.m.

Institute of Road Transport Engineers

DURHAM
"Lighting for Commercial Vehicles and Its Contribution to Road Safety," by K. J. Jones. North-East England Group. Three Tuns Hotel, Durham City. Tues., Sept. 21, 7 p.m.

LEEDS
"Lubricants and Greases for Road Transport Vehicles," by Dr. E. M. Dodds. Yorkshire Centre. Hotel Metropole, King-street, Leeds, 1. Thurs., Sept. 16, 7.30 p.m.

LIVERPOOL
Discussion on "Commercial-Vehicle Electrical Equipment." North-West Centre. Adelphi Hotel, Liverpool. Wed., Sept. 22, 7.30 p.m.

MANCHESTER
"The Advancement of the Diesel Engine," by H. L. Parrish. North-West Centre. Engineers' Club, Albert Square, Manchester. Mon., Sept. 13. 7.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Current American Practice in Heating, Ventilating and Air Conditioning," by J. K. M. Pryke. Institution of Mechanical Engineers, 1 Birdcage-walk, Westminster, S.W.1. Tues., Sept. 14, 6 p.m.

Institution of Locomotive Engineers

LONDON
Presidential Address by A. Campbell. Institution of Mechanical Engineers, 1 Birdcage-walk, Westminster, S.W.1. Wed., Sept. 22, 5.30 p.m.

Institution of Production Engineers

BIRMINGHAM
"Abrasives" (with film) by A. C. Turner. Birmingham Graduate Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Sept. 14, 7 p.m.
"Time, Space and Productivity," by A. B. Waring. Birmingham Section. College of Technology, Suffolk-street, Birmingham, 1. Wed., Sept. 15, 7 p.m.

COVENTRY
"The Effective Use of Materials," by F. Nixon. Coventry Section. Craven Arms, High-street, Coventry. Tues., Sept. 21, 7 p.m.

LUTON
"Industrial Law: Legal Aspects of Factory and Production Management," by H. P. Jost. Luton Graduate Section. Peahen Hotel, St. Albans. Mon., Sept. 13, 7.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)

Labour Notes

T.U.C. AT BRIGHTON

Although German rearmament and other problems of a mainly political character will doubtless have occupied much of the time of the one thousand delegates attending the 86th assembly of the Trades Union Congress, which is being held at Brighton and opened last Monday, many matters of great industrial significance will have been considered also.

One of the most important of the matters due to be debated was the question of extending public ownership to other industries, and, on this subject, a composite resolution was agreed to by the T.U.C. General Council during their three-day conference prior to the opening of the full meeting of delegates.

The resolution was so worded as to eliminate several of the more obvious grounds for controversy. There was, for example, no reference to the *Plan for Engineering*, developed some time ago by the Confederation of Shipbuilding and Engineering Unions, although the *Plan* was supported in one of the original motions presented to the Congress, for consideration at the Brighton meeting, and in one of the amendments. The *Plan* was the cause of much dispute, especially since Mr. Arthur Deakin referred to it as a "mumbo-jumbo of meaningless words and phrases."

One sentence in the General Council's resolution likely to have been challenged was that which read: "Congress confirms its support for the principle of the social ownership of basic industries, including certain sections of the chemical and engineering industries."

NOT ENOUGH SPENT ON RESEARCH

In his presidential address to the Congress, Mr. Jack Tanner emphasised that improved living standards could be achieved only by improving individual production. Mr. Tanner said that this did not mean working harder or longer, but more efficiently. By using modern machinery, it was possible to take the "slog and sweat" out of work.

There was no intention of halting progress, but trade-union members must be protected against adverse circumstances and receive their just share of the benefits of greater productivity.

Turning to the question of Britain's industrial position, he declared that not enough money was spent on research. Britain did not spend nearly as much in this connection as other countries with less difficult export problems.

Other points he emphasised were that a lower rate of capital investment in this country than in the United States or Germany could seriously affect Britain's economic position, and that both industrial and domestic consumers indulged in an almost criminal waste of fuel. Organised employees had shown that they were prepared to co-operate in creating an efficient productive economy but it was essential that industrialists and the Government should play their parts.

PASSING OF CONTROLS REGRETTED

Much stress was laid in the economic section of the General Council's report to the meeting on the difficulties which would arise in Britain from any recession of trade in the United States. The Council returned to this theme several times.

The policy adopted by the Government of lifting controls wherever they could had rendered the economy of this country much more vulnerable to the effects of any such recession.

In the absence of positive signs that the American Government intended to co-operate in international commodity agreements, to increase their overseas investments, and to adopt a more liberal import policy, it was essential that Britain should seek the assistance of other countries in the sterling area, if a high level of employment was to be maintained and her dependence on the dollar area reduced.

The Council expressed their great regret at the relaxation of exchange controls, rumours of a possible return to the convertibility of sterling, and the de-nationalisation of some sections of industry. These measures, they said, had weakened the Government's ability to maintain investments at the level necessary for full employment.

The tendency for shareholders' incomes to rise was also deplored. In this connection, any appreciable addition to the prices of export goods, resulting from pressure for higher incomes, would be bound to have repercussions on Britain's ability to compete in foreign markets.

Trade unionists could not be expected to stand idly by while improvements they had secured were whittled away by action or inaction on the part of the Government or by attempts on the part of the richer sections of the community to improve their position.

INVESTMENTS SHOULD BE ENCOURAGED

Trade unions, the Council stated, had shown that they were prepared to act with common sense, provided that other sections of the community did not take advantage of this.

The need for moderation had not passed, but that did not mean that there should not be necessary wage improvements, or that working people were not entitled to benefit from improvements which their efforts had made possible. It did mean that the only sure way to raise living standards was by increasing efficiency.

There was a danger in the Government's assumption that investments would be made where they were most needed, if the decisions were left to competing business men. This, the Council suggested, was illustrated by a fall in the total of fixed investments last year.

As long as private manufacturers were not certain of selling their products, they would be relucant to spend money on making their businesses more efficient. It was essential that every Government should provide incentives, where necessary, to stimulate investments.

The most satisfactory means of securing the co-operation of trade unionists in increasing production and holding down costs and prices was to convince them that the Government, as well as other sections of the community, were playing their parts.

NEED FOR MUTUAL UNDERSTANDING IN SHIPBUILDING INDUSTRY

References to the strong competition facing the British shipbuilding industry from foreign shipyards were made by Mr. G. H. Houlden, M.B.E., managing director of the shipbuilding division of Vickers-Armstrongs Limited, in the course of a speech on August 31 at the launch of the British Sovereign at Barrow-in-Furness.

He said that there were many stiles to be surmounted in the economic race ahead. If these were to be satisfactorily overcome, there would need to be a mutual understanding between workpeople and managements in the industry greater than ever before.

This applied particularly to a shipyard geographically situated as Barrow was and where vessels of every type were constructed. The completion of one vessel required the immediate commencement of the next, if the balance and continuity of employment of the firm's workpeople were to be maintained.

Shipbuilders no less than shipowners had their economic problems to face. The incidence of high taxation and the lack of fixed prices affected both sections. In the case of a large oil tanker, such as the British Sovereign, some two-thirds of the cost was absorbed by materials and supplies, and over these items the shipbuilders had little control. The remaining one-third, comprising wages and oncost, was largely, but by no means wholly, within the control of the shipbuilders.

Vickers-Armstrongs, whose two shipyards were responsible at the present time for some 10 per cent. of the total annual output of British merchant shipping, were very conscious of the contribution which these yards must make to maintain the country's mercantile marine at an efficient and economic level.

COLLIERY OVERTIME BAN LIFTED

At a mass meeting of miners at Rotherham last Sunday, which was attended by nearly one thousand employees from Thurcroft Colliery, it was decided by a large majority to suspend the ban on overtime at the pit. The ban was imposed on August 30 as the result of a dispute over wage rates. Local officials of the National Union of Mineworkers informed the men that the colliery management had conceded their claims, in most of the 250 cases put forward, and that the miners concerned would receive their full pay and bonus.

There were some complaints regarding the alleged "discourtesy" of the pit management to the union's branch officials, and the men decided to submit a protest to the chairman of the North-Eastern Divisional Coal Board, Major-General Sir Noel Holmes, K.B.E.

Another resolution passed at the meeting demanded that permanent area officials of the union should be subjected to re-election at five-yearly intervals. There were also complaints regarding a letter received from the union's Yorkshire area headquarters. This was stated to have criticised the imposition of the ban on overtime and the lack of co-operation with the pit management.

EMPLOYMENT RECORD PASSED

The high level of employment in Britain, reached during recent months, continues to rise. So much so, that the level at the end of June, which constituted a peace-time record, has since been passed, according to statistics issued by the Ministry of Labour and National Service.

At the end of July, the number of persons in civil employment (industry, commerce and services of all kinds) was 22,515,000, representing an increase of 50,000 persons during the month. This increase comprised 15,000 men and boys and 35,000 women and girls.

Employment in the manufacturing industries as a whole increased by 19,000. The most marked change in this group was an increase of 20,000 persons engaged in the food, drink and tobacco industries. This change was partially seasonal.

During the twelve weeks ended July 28, 1954, employment exchanges filled 691,000 vacancies, compared with 678,000 vacancies in the corresponding period last year. The number of vacancies notified to the exchanges, but unfilled, on July 28 last was 383,000 or about 62,000 more than on July 29 last year. Unemployment increased between July 12 and August 9 last, mainly owing to young persons leaving school.

The total number of persons registered as unemployed on August 9 last was 239,600, of whom some 8,800 were only temporarily out of work. Unemployment at that date was 1·1 per cent. of the estimated total number of employees, compared with 1·0 per cent. in July and 1·4 per cent. in August, 1953.